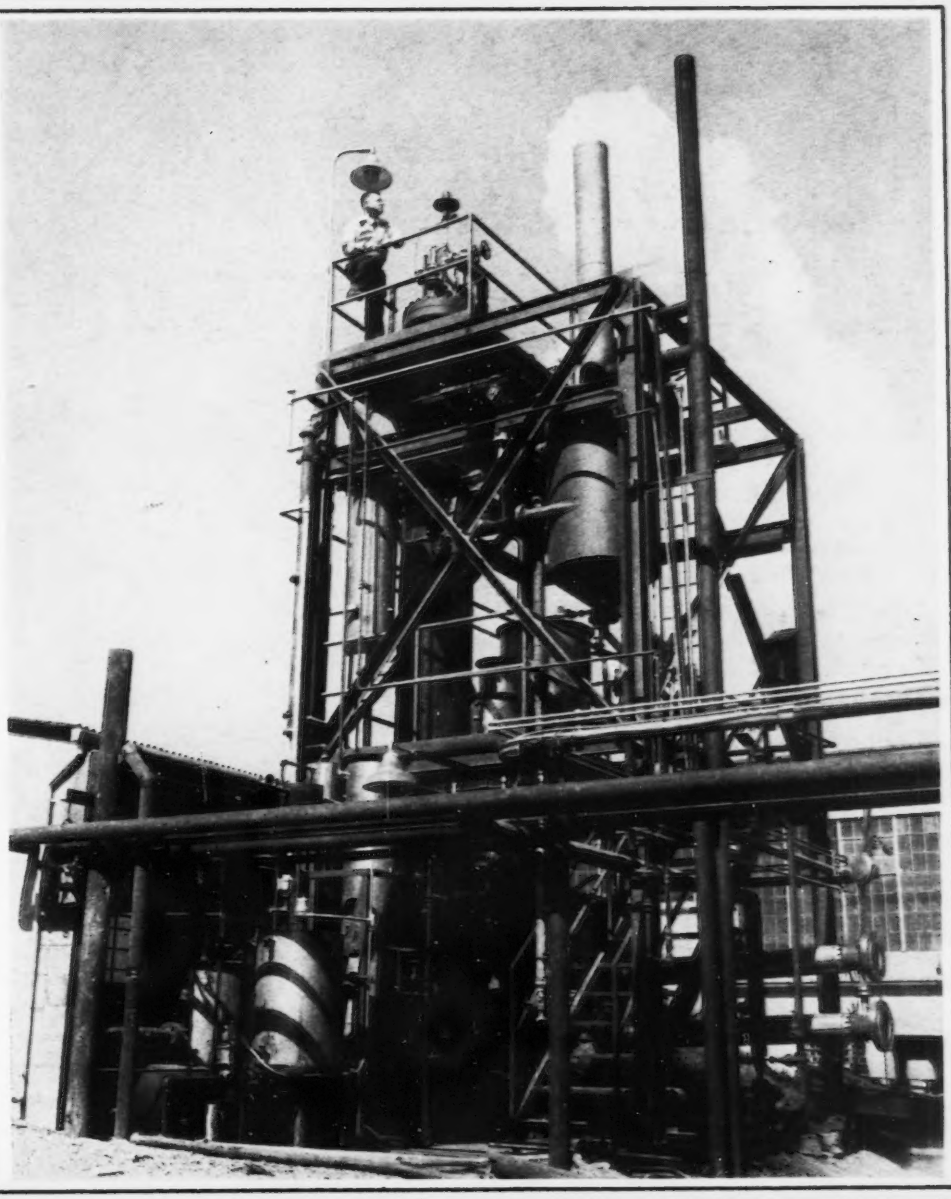
Forest Products Journal

QUALITY CONTROL IN THE SAWMILL—P. 444

Featured in This Issue:

Chemical Utilization

- Present Status of Lignin
- Lignin Dimethyl Sulfide Process
- Properties, Uses of Levulinic Acid
- Composition of Aspen Bark



Dimethyl sulfide is produced from by-product lignin recovered from spent kraft liquor in this Crown Zellerbach plant at Camas, Washington.

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CYANAMID

ADHESIVE NEWS

"We cannot afford to use any other adhesive than URAC® 185"

says ***MARK PRICE, president of Desk Tops Inc., Cleveland, Ohio***

Claiming 75% of the market for school desk tops east of the Mississippi, Desk Tops Inc. cannot afford a faulty glue line in its laminated tops.

Mr. Price says, "A delamination caused by a faulty glue line is unheard of by this company. Our customers expect us to guarantee our tops against this failure. Consequently, we believe we *must* continue to use URAC 185, which has served us so well."

URAC 185 makes one of the strongest possible joints between the hardwood plywood cores and rich melamine plastic surfaces. It is both gap-filling and craze resistant, and so moisture resistant that tests have shown wood to deteriorate before the bond. Moisture resistance is particularly welcome in cafeteria table tops, for it eliminates the risk of edge delamination starting from wet spills or washing.

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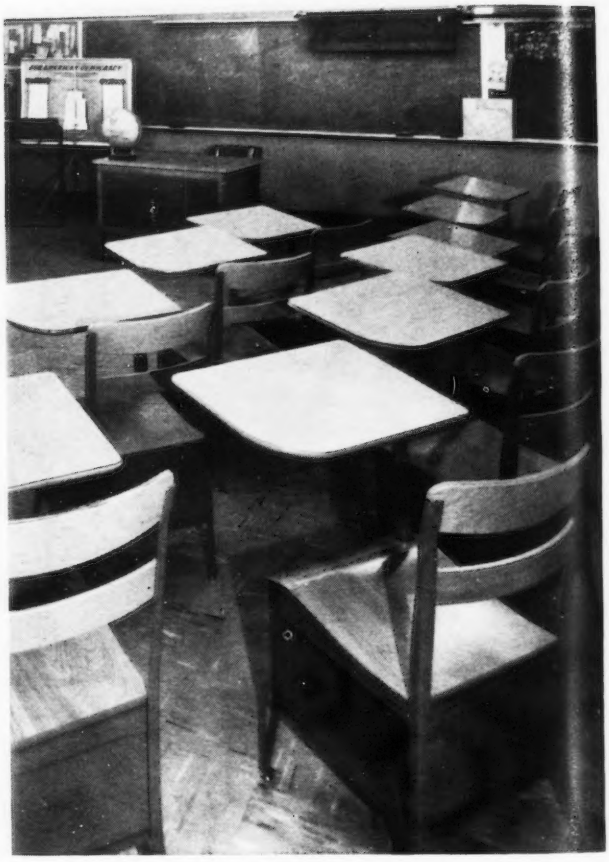

Plastic desk tops are here to stay—about 80% of all school furniture sold last year "went plastic." Big supplier of plastic tops for desks and tables is Desk Tops Inc., which accepts no substitutes for URAC 185 Resin Adhesive as the bonding agent.

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Annual subscription rate, $15.00; single copies $1.00, except October Yearbook Number, $4.00. Annual subscription rate is $11.25 with voting, associate, and supporting memberships in the Society. Remittances should be made payable to the Forest Products Research Society.

Correspondence on editorial matters should be addressed to the Editor, at the Executive Office. The Society is not responsible for views expressed in publications.

FOREST PRODUCTS JOURNAL

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IMPORTANT FPRS DATES

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Jan. 20–21, 1958: Pacific Northwest Section Meeting, Corvallis, Ore.

Mar. 30– Apr. 1, 1958: Joint Northeast–Eastern Canadian Section Meeting, Syracuse, N. Y.

May, 1958: Pacific Northwest Section Meeting, Seattle, Wash.

May 1–2, 1958: Northern California Section Meeting, Berkeley, Calif.

June 22–26, 1958: Twelfth National Meeting, Madison, Wis.

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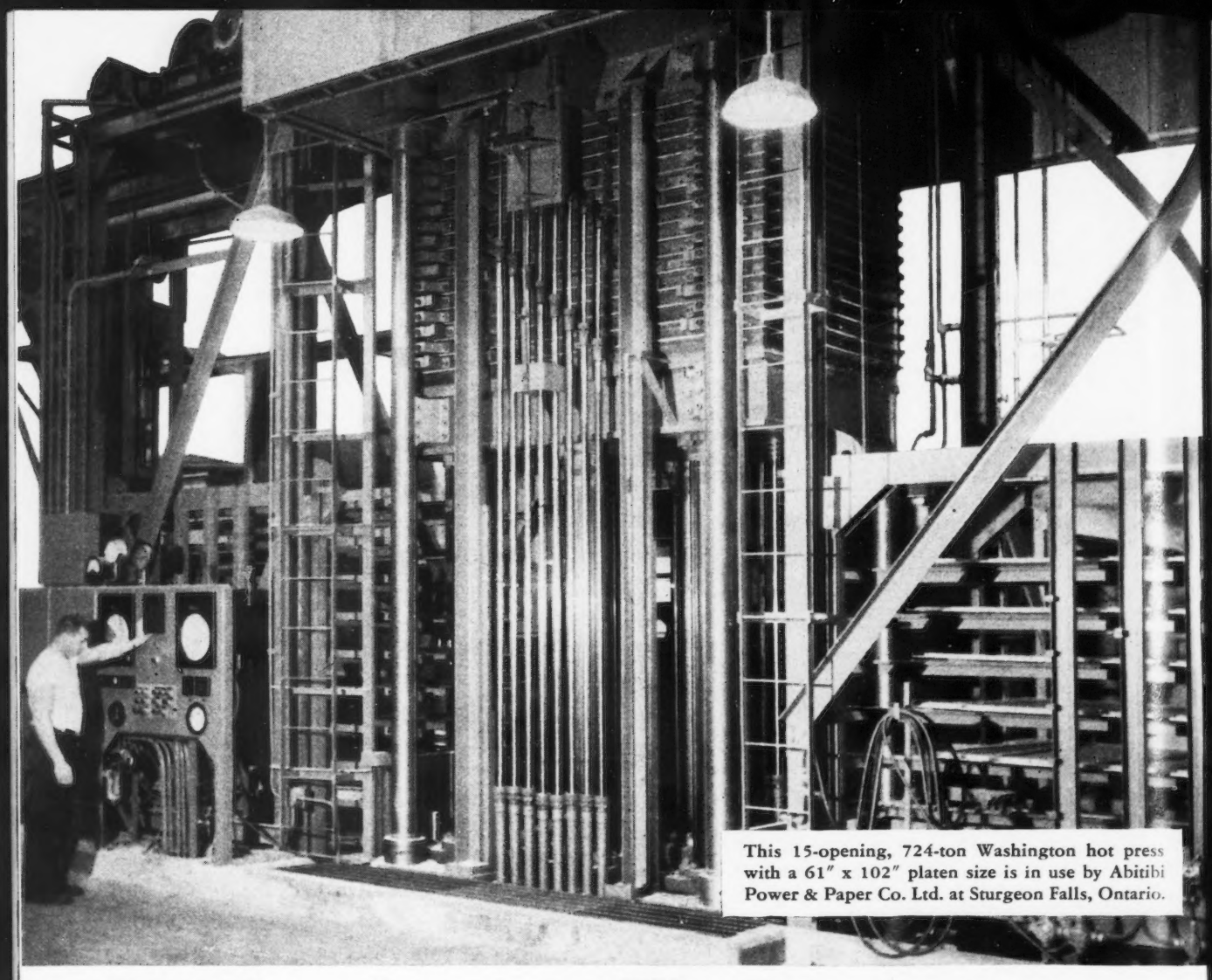

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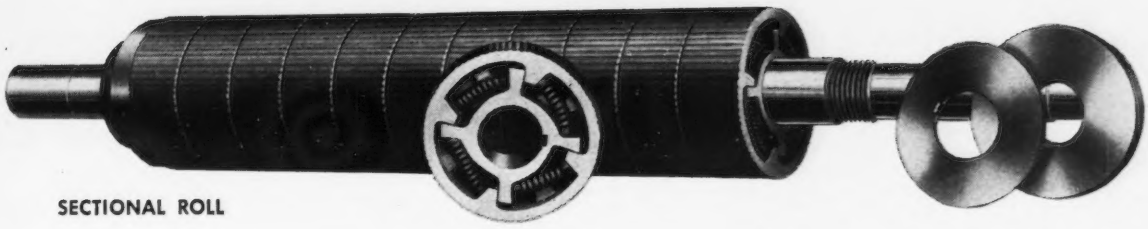

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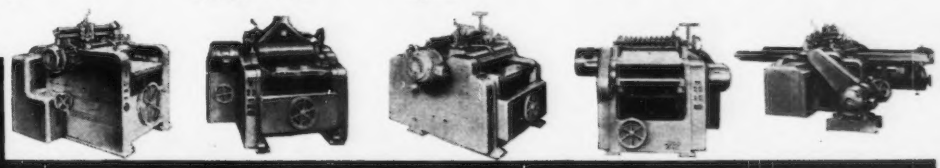

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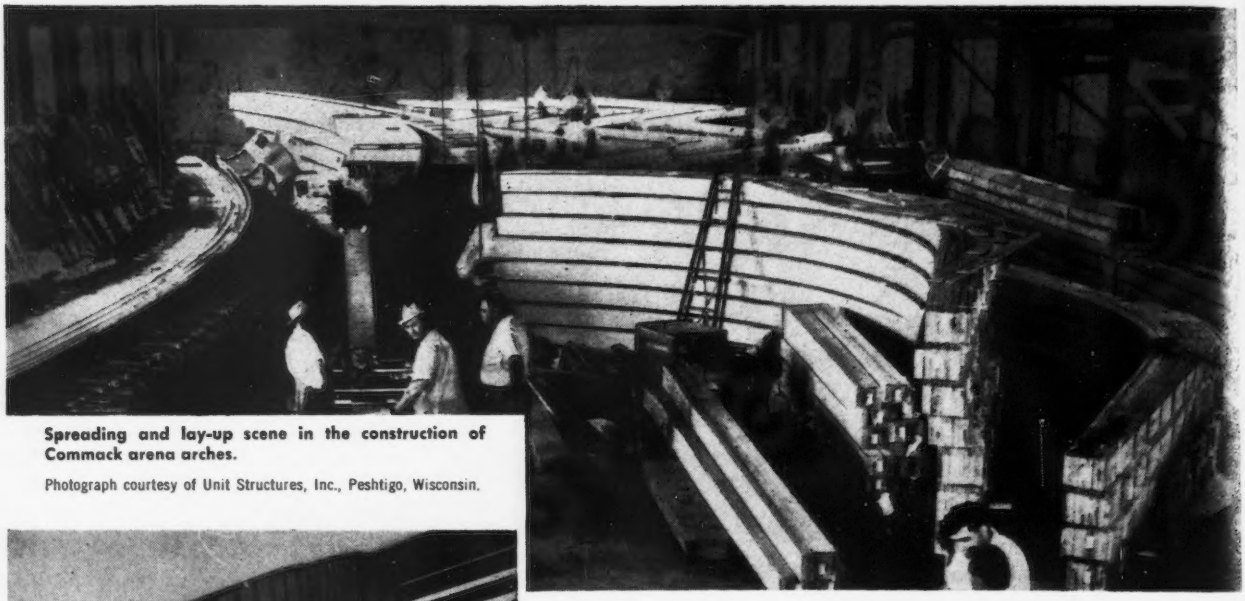
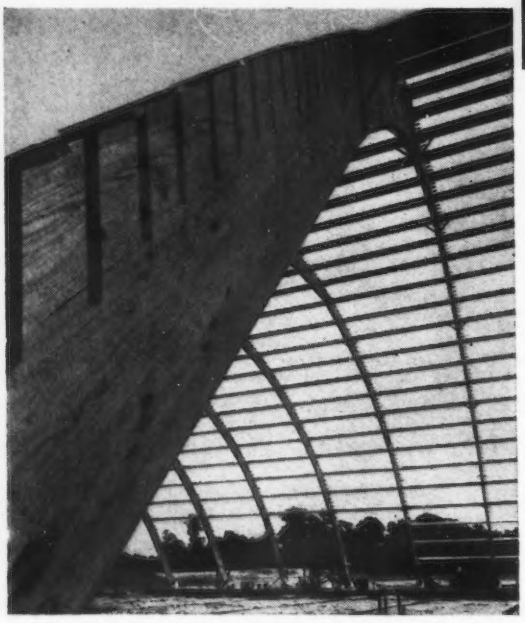


Spreading and lay-up scene in the construction of Commack arena arches.

Photograph courtesy of Unit Structures, Inc., Peshtigo, Wisconsin.



PENACOLITE-laminated arches like these are erected rapidly and economically. Moreover, the natural beauty of wood is preserved in the basic construction. Twelve of these giant arches were erected for the Commack, Long Island arena last summer.

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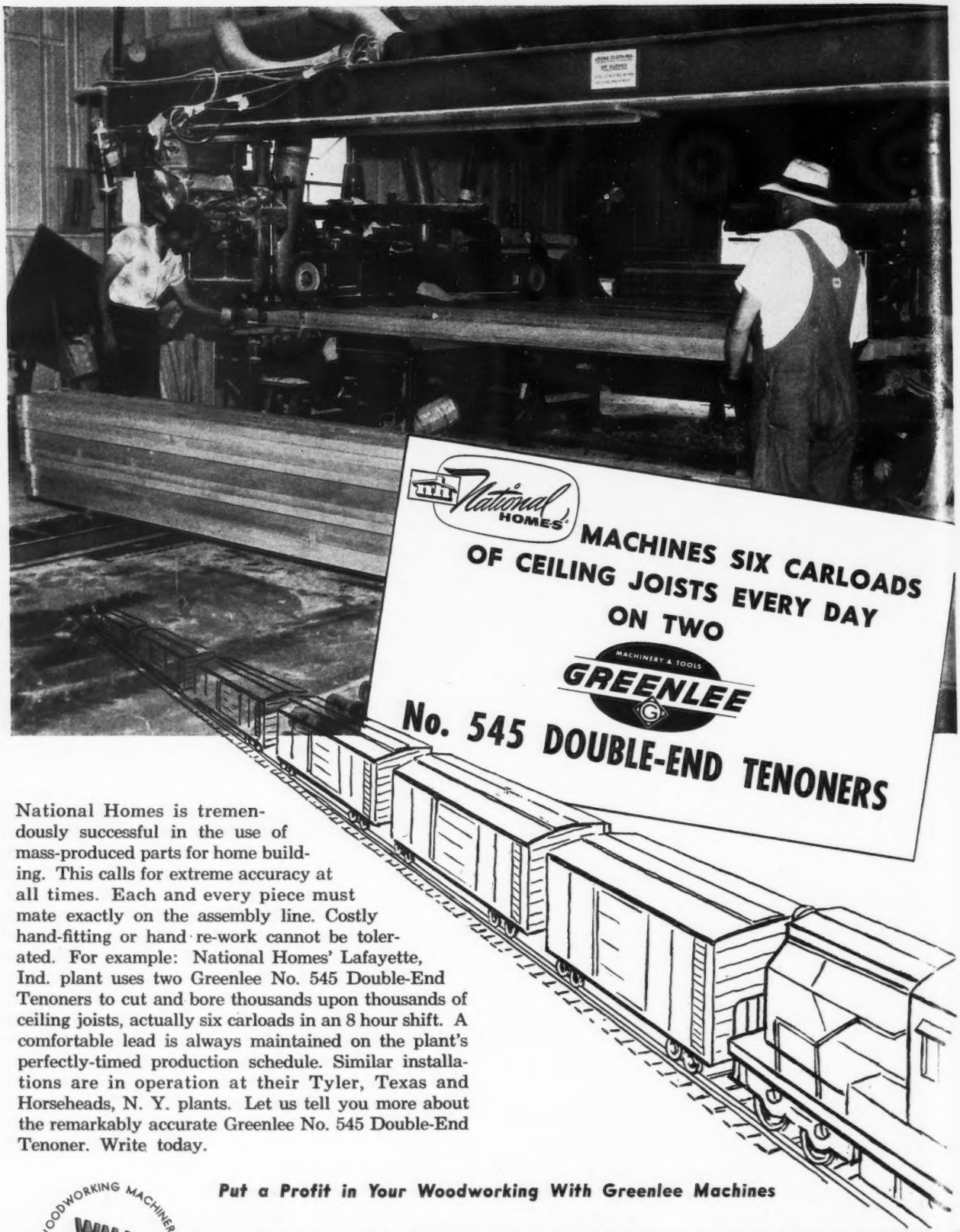

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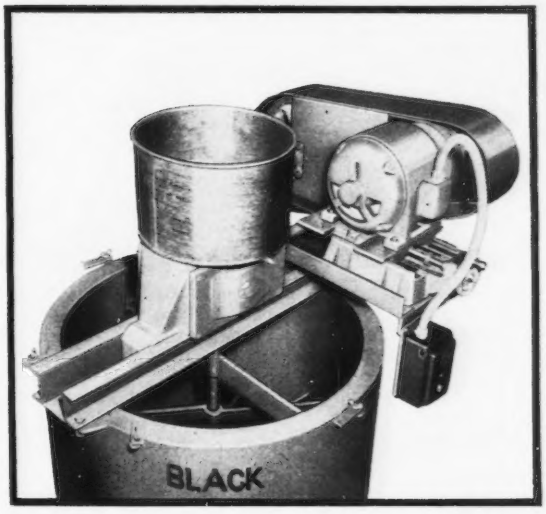

TWO-WAY AGITATION ▶

To the right is a partial view of a 60 gallon cold glue mixer arranged with a variable speed drive and water jacket. The covers have been removed showing accessibility for cleaning, and also the double agitator arrangement. Note the thick double walled tank permitting free circulation of water for cooling the glue batch.

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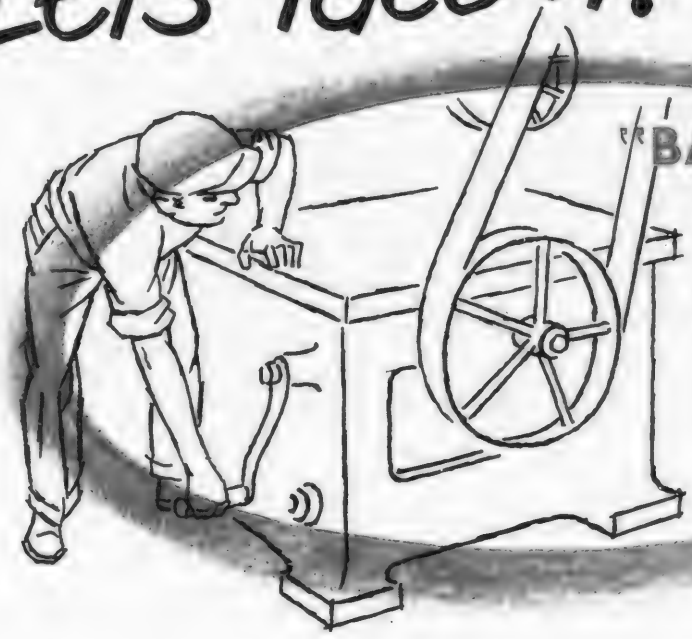

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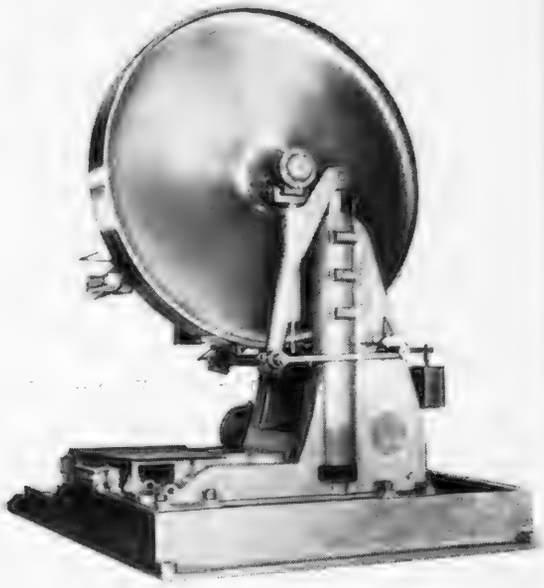

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FPRS NEWS-DIGEST

Volume VII DECEMBER, 1957 Number 12

Building Contract Signed, Fund Exceeds $37,000

Site of the future home office of the Forest Products Research Society

Material Donations Being Coordinated by Heyer

The building contract for the FPRS Executive Building was expected to be let in mid-December, to contractor Leo R. Jenness, Madison, Wis. The contract calls for ground breaking in December, weather permitting. According to the building schedule, excavation and concrete foundations should be completed by the first of the year.

Three sets of laminated beams and arches donated by Unit Structures and two sets contributed by Rilco Laminated Products, Inc., are in production and are expected at the building site about Feb. 1, 1958.

Selection of other building materials is now underway. Materials are being accepted on the basis of priority of contribution. Construction is under the

Cash Contributions Since August 1957

American Mfg. Co., Inc.
L. W. Anderson
F. R. Armbruster
Robert S. Bader
Bagnal Lumber Co.
Dr. John S. Bates
Bauer Bros. Co.
Herbert L. Becher
Ben Benioff
James S. Bethel
Louis H. Bock
Louis J. Bogolin, Jr.
A. B. Bonutto
H. E. Bovay, Jr.
Box Planing Mill
Dudley C. Carey
James H. Carr, Jr.
Casswood Industries, Inc.
E. Garth Champagne
Chris-Craft Corp.
Ernest A. Clevenger
Harold A. Core
R. W. Cowlin
Chas. O. Cox Corp.
H. C. Crandall
Lee W. Crandall
Richard C. Crouch
Darling & Co.
Darlington Veneer Co., Inc.
Albert Dietz
Domion Electrohome Industries
Dow Chemical Co.
D. E. Ellis
Eppler Wood Products Co.
Harvey D. Erickson
Evans Products Co.
D. L. Fair Lumber Co.
Fiberesin Plastics Co.
Fibreboard Paper Products Corp.
Fleming & Sons, Inc.
W. S. Fox & Sons
Emanuel Fritz
G. E. Foltz
FPRS Great Lakes Section
FPRS Mid-South Section
FPRS Mid-West Section
Hereford Garland
General Plywood Corp., Inc.
The Gibbard Furniture Shops
James W. Gilman
Peter M. Graham
E. Russell Greenhood
Grenco, Inc.
Henry W. Haigh
Irving L. Halsted
Donald J. Harbach
The Harmony Co.
Henderson Furniture Ltd.
Henrich Lumber Co.
Hermsdorf Fixture Mfg. Co.
Norman C. Higgins
Edward Hines Lumber Co.
Charles H. Hoffman
Marx Hyatt
J. A. Hauter
Hatheway & Patterson Co., Inc.
C. T. Jensen
G. F. Jewett, Jr.
C. W. Johnson
Thomas D. Johnson
Kappler Lumber Co.
Kay Musical Instrument Co.
Richard G. Kimball
Jack W. Kniffen
Lakeland Door Co.
G. M. J. Lambert
Laminated Rafters Corp.
Laminated Veneers Co., Inc.
Richard D. Lane
Richard W. Lloyd
J. Dewey Long
Love Wood Products of Texas
MacCraft Industries
L. M. Manley
Byrne C. Manson
Mattison Machine Works
E. J. Maxwell, Ltd.
McCully Woodworking Shop
Mill Equipment, Inc.
J. B. Millar
Monsanto Canada, Ltd.
Monsanto Chemical Co.
Mississippi Products, Inc.
Nuodex Products Co.
A. W. Olson
Orono Wood Products
Orton Machine Co.
Packard-Bell Electronics
Benson H. Paul
Plastics Engineering Co.
Ply-Curves, Inc.
Gerald F. Prange
E. V. Prentice, Inc.
Preston Woodworking Machinery Co.
Robert C. Purcell
R. B. Putman
Reichhold Chemicals, Inc.
William H. Reid
Richton Tie & Timber Co.
Rilco Laminated Products, Inc.
Walter C. Ring
Dr. J. Risi
J. N. Rudnicki
K. W. Rymer
Sandewll & Co., Inc.
Arno P. Schniewind
Dale L. Schubert
James O. Searer
Sheffield Doors, Inc.
S. M. Simpson, Ltd.
Harvey H. Smith
Myron W. Smith
Star Machinery Co.
Rudolf Susanik
Tilghman Lumber Co.
Tiller Tie & Lumber Co.
Timber Engineering Co. Staff
Tree Farmers, Inc.
Harry G. Uhl
Unit Structures, Inc.
Victoriaville Furniture, Ltd.
James C. Ward
Washington Lumber Co
Paul Watts, Inc.
Ted C. Weill
Western Plywood Co., Ltd.
Ronald A. Whyte
J. K. Wilson
Willingham Sash & Door Co.
Elwayne Zerba

supervision of Otto Heyer, architect, U. S. Forest Products Laboratory.

Estimated building fund totals to date are $37,686.86. If you or your company have not yet contributed, you may wish to use the coupon at the right.

Cash contributions since the last report to the membership in the August JOURNAL are listed on the preceding page. Pledges are listed to the right.

Technical Sessions Scheduled by Nat'l Meeting Committee

Fifteen technical sessions have been scheduled for the 1958 National Meeting, June 22–27, 1958, at Madison, Wis., according to R. L. Hiller, general chairman of the meeting committee.

A keynote session has been added to this year's agenda, in which the inter-relatedness of industry, government, and education will be the main topic.

Wood Composition Board and Wood Machining, Sessions I and II respectively, have been scheduled for Monday morning, June 23. The afternoon has been set aside for the Keynote session (III). Veneer & Plywood (IV), Wood Preservation (V), and Industry–Education (VI), will be held Tuesday morning June 24, with Logging, (VII), Glues & Gluing (VIII), and Quality Control (IX) designated for the afternoon.

Wednesday morning, June 25, has been set aside for Division Business Meetings, with Wood Composition Board (X), Wood Drying (XI), Wood Finishing (XII), and Chemical Utilization—General (XIII), in the afternoon. Thursday morning, June 26, will be devoted to Lumber Manufacturing (XIV) and Chemical Utilization—Lignin (XV).

Mid-West Section Adds $1,275 to Building Fund

Wood in Home Construction was the theme of the Mid-West Section Meeting, Nov. 14–15, at Milwaukee, Wis. At the official luncheon, Nov. 14, J. J. Allegretti, on behalf of the Section, presented President Kaufert with $275 in contributions resulting from Mid-West solicitation. In business action, the Section voted to donate $1,000 to the Building Fund. The Section had previously donated a total of $1500 to the fund.

Officers for the coming year are Dwight W. Bensend, Iowa State College, chairman; William A. Kluender, C & N. W. Railway System, vice chairman; Harvey J. Gill, Jr., Carr, Adams & Collier Co., secretary; Robert Archambeault, National Casein Co., treasurer; and Hugh D. Welch, Jr., Iowa Missouri Walnut Co., membership chairman

Trustees are J. J. Allegretti, Masonite Corp.; Gustave Barshefsky, Elmendorf Research, Inc.; L. J. Fitzpatrick, J. J. Fitzpatrick Lumber Co.; Jack Koellish, Wood and Wood Products; T. Walter Noble, Decar Plastic Corp.; and Charles S. Walters, Illinois Agric. Exp. Sta.

Topic of the first technical session was Composition Board in Home Construction, with D. W. Bensend as moderator. Tom Swearingen, Masonite Corp., spoke on "The Potentials of Hardboard in Prefabrication." He pointed out that in the last 50 years there has been less progress in farm building than in any other phase of agriculture. "Particle Board in the Building Field" was the subject of a paper by Wayne C. Lewis, U.S. F.P.L.

A plant tour of Harnischfeger Homes, Inc., took place the first afternoon of the meeting. The 44 participants were shown the production steps involved in prefabrication of house sections. Fabrication of nailed glued roof trusses was inspected and four models of Harnischfeger Homes were also shown.

The second technical session, moderated by Otto C. Heyer, U. S. Forest Products Lab., was on the topic of Glued Wood Products in Home Construction. Stanley Suddarth, Purdue University, spoke on "Glue as a Structural Connector". "Plywood in Home Construction" was the topic of a paper by William Roddis, Roddis Plywood Corp., and was presented in the author's absence by Leonard Ropella, of the same firm. J. D. Lincoln, consultant with Continental Can Co., spoke on "Sandwich Construction in Prefabrication".

The last session of the meeting, a panel discussion on The Application of Wood in Prefabrication, was moderated by John Normile, Building Editor, Better Homes & Gardens. Panel members included: R. A. Jones, Small Homes Council; Clarence Thompson, Lumber Dealers Research Council and Williard J. Worth, National Homes Co.

At the business meeting, L. J. Fitzpatrick gave a brief report on the NLMA meeting in Washington, with emphasis on the promotion of wood products. Speaker at the official luncheon was F. H. Kaufert, who reported on progress of the National Office Building.

Preprints of Northeast Meeting Papers Available

Imported woods, modifying wood for use, and handling of wood products are the subjects covered in preprints of papers delivered at the recent fall Northeast Section meeting held in New York City. Preprint copies that include eight papers are available at $2 per copy from Richard F. West, Northeast Section publications coordinator. Requests should be addressed to Mr. West, Head, Forestry Dept., College of Agriculture Rutgers University, New Brunswick, N. J.

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I hereby (contribute) (pledge) my support to the proposed FPRS Executive Office Building to be erected as early as possible, consistent with conservative business practice, in Madison, Wisconsin.

(Check here for Contribution and enclose check or money order) ☐ $_____

(Check here for Pledge. We will invoice you for the amount of pledge during calendar year 1958) ☐ $_____

Signed _____

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Androc Chemical Co.
Baugh Bros. Co.
A. Clairmont
R. D. Deckert
J. J. Fitzpatrick Lumber Co.
Eric Gourdeau
S. I. Kalmich
Knox Corp.
The Koppers Co.
R. H. Lillyblad
Calixto Mabesa
John T. McGinn
J. H. Miller
Morgan Lumber Sales
Osgood H. Munger
Harold A. Oehlerich
Potlatch Forests, Inc.
Protexol Corp.
Cornelius Reckers
James A. Richolson
J. R. Roberts
Robert M. Sand
Russell K. Stensrud
A. R. Tegge
Warren S. Thompson
Ben M. Turner
Clarence F. Van Epps
The Wel-Den Co.
S. A. Woodruff

Wood Award Rules for 1958 Announced

Annual Competition Launched

Rules for the 1958 Wood Award competition, a contest established in 1948, have been announced. The competition is open to graduate students in attendance for at least one quarter or semester at any North American university or college between January 1, 1957, and April 30, 1958. The Awards are presented by Wood and Wood Products magazine in cooperation with the FPRS Industry-Education Division.

Two cash awards and certificates will be given for papers based on research conducted by graduate students. The first place winner will receive $350 and second place, $150, with the awards to be presented at the FPRS Twelfth National Meeting, June 22–27, 1958. The winner of the first award will be invited to present his paper at the Madison meeting.

Deadline for submission of tentative titles is April 15, 1958. The complete paper must be submitted in triplicate by May 1, 1958, to the FPRS Executive Secretary, Box 2010, University Station, Madison 5, Wisconsin. Judges will be announced later.

First recipient of the Wood Award was N. V. Poletika, who received it in 1948 for his paper on "A New Method for Studying the Elastic Behavior of Wood." Poletika was director of research for the Timber Engineering Co. from 1955–1957. He recently resigned this position to become director of research and development for Union Lumber Co.

The 1957 first-place winner was R. L. Youngs, U. S. Forest Products Lab., who received the award for his paper on "Mechanical Properties of Red Oak as Related to Drying", which was based on a dissertation he submitted as a candidate for a Ph. D. in Forestry at Yale University. "The Relation of Mechanical Properties of Wood and Nosebar Pressure in the Production of Veneer", was the title of the second-place paper by Charles W. McMillin, Ann Arbor, Mich. A total of 15 entries, representing seven colleges and universities, was entered in the 1957 competition.

The 1956 winners were Selwyn Fox, University of Toronto, for his paper on "An Investigation into the Effects of Certain Variables in Scarf-Jointed Timber Laminations"; and Norman C. Higgins, for his paper based on studies at Penn. State University on "The Effect of Species on the Relative Humidity-Equilibrium Moisture Content Relationship".

Rocky Mountain Section Holds Successful Meeting

Forty members and guests attended the meeting of the recently formed Rocky Mountain Section, held Nov. 8, at the Cosmopolitan Hotel, Denver, Colo., according to L. A. Mueller, secretary-treasurer of the Section. In his speech after the technical session FPRS President Kaufert complimented the section on its fine start.

Featured speaker of the technical session on the theme of Waste Wood Utilization was George G. Marra, Washington State Institute of Technology, who discussed "Particle Board —Products and Processes". Mr. Marra traced the development of the particle board from its origin in Germany in 1940 to the present day, and outlined processes and present trends in the industry.

Harry E. Troxell, Colorado State University, referred to wood waste as the "Fourth Dimension", emphasizing its importance economically and from the standpoint of timber resources in the face of a rapidly expanding population. F. B. Joy, Ace Box Co., gave an illustrated talk on his firm's major products, the forms of waste that resulted, and efforts to minimize such losses.

Electronic equipment for the rapid setting of glue bonds was discussed by R. S. Bader, Raybond Electronics, Inc., in his speech entitled "Electronic Edge Gluing and Finger Jointing". Ray Armstrong, Hallack & Howard Lumber Co., reviewed his personal experiences to utilize vast volumes of wood that went into the burners. He described the success of his firm in developing a market for pulp chips. Cost and production aspects on installation of suitable chipping and handling equipment were outlined by Mr. Armstrong.

W. R. Fritze, Section vice chairman, served as program chairman. A spring meeting was tentatively scheduled for May of 1958. In further business, the Section voted to establish a committee on Research and Development. Prof. Troxell, on request of Section Chairman Schumburg, agreed to serve as chairman of the committee and to appoint a group to work with him.

1959 National Meeting Committee Organizes

The 1959 National Meeting Committee met for the first time October 30, 1957, at the University Club, San Francisco, Calif., to deal with organizational details. Standing, l. to r.: William G. Van Beckum, Homer N. Stephenson, Victor Roth, James C. Rowney, Robert M. Kuhn, Peter Field, and Byrne C. Manson. Seated are Fred Dickinson, Raymond H. Berry (Chairman), and N. Thomas Shelton.

At a dinner given by R. H. Berry, preceding the meeting, were, standing, l. to r.: Byrne C. Manson, N. Thomas Shelton, Homer N Stephenson, James C. Rowney, R. H. Berry, Fred Dickinson, Robert M. Kuhn, Victor Roth, Peter Field, William G. Van Beckum. Seated, l. to r., are: Mrs. Peter Field, Miss Elizabeth Davenport, Mrs. W. G. Van Beckum, Mrs. Homer Stephenson, Mrs. N. T. Shelton, Mrs. F. Dickinson, Mrs. V. Roth, Mrs. R. M. Kuhn and Mrs. R. H. Berry.

Practical Sessions Featured at Ohio Valley Meeting

Sterling Durst discusses rough mill procedure.

D. C. Carey, immediate foreground, leads discussion on packaging.

Evening discussion speakers on small tools.

Left to right, Paul Fenn, Sterling Durst, J. Habig, John Young, John Wilson, and Henry Espel.

Discussion Sessions Featured at Ohio Valley Fall Meeting

"How to do it" discussion sessions were featured at the Ohio Valley Section Meeting, Oct. 17–19, at New Albany, Ind. Held Thursday afternoon were two discussions, one on Finishing, moderated by R. F. Wilder, Louisville, Ky., and the second on Packaging, moderated by D. C. Carey, Louisville, Ky.

Packaging is a $12 billion industry Carey said, and is in need of new source material for the designing of containers. During the discussion, it was pointed out that, in metropolitan department stores, "clean up" after unpacking merchandise can amount to 10 to 15 per cent of sales cost.

John Lutz, U. S. Forest Products Laboratory, presented a paper by himself and Dr. H. O. Fleischer on "New Products from the Veneer Slicer". He mentioned aspen, southern pine, overcup oak, and hickory as possibilities for uses in veneer and plywood. In answer to the question "How thin can veneer be sliced?", he replied, within a range of 1/200 to ½ inch. The trend, he said, is toward thinner natural veneers on smooth surfaces such as are provided by hardboard. Lutz concluded by saying that Laboratory studies indicate that the demand for sliced veneer is going to double in the next 25 years.

The evening session was devoted to a discussion and display of small tools and equipment. The tool manufacturers expressed the thought that in general the woodworking industries are far behind metals and plastics in mechanization and automation because of the obsolescence of equipment now in use.

Sanding was the topic of a discussion session held Friday morning and moderated by Paul Hoffman, Jasper Novelty Furniture Co. The last discussion of the meeting was on Rough Mill Procedure with Ed Telle, Smith Cabinet Co., as moderator. A plant tour of the Smith Cabinet Co., Salem, Ind., wound up the meeting.

A Sawdust and Chips Buffet was featured Thursday evening, Oct. 17, and a noon Smorgasbord Luncheon was held on Friday, October 18.

New officers are: Paul Fenn, Tell Chair Co., chairman; Sterling Durst, Gamble Bros., vice chairman; and John R. Young, Altawood, secretary.

Plant Tour Featured at Northern California Meeting

A plant tour showing the complete processes used in making various Masonite products, from the dumping of chip cars or trucks until the finished product is placed in the warehouse was the highlight of the Northern California Section Meeting, October 25, at Ukiah, Calif. Registration at the meeting was 69 members and guests, the largest attendance for a semi-annual meeting held by the Section.

Speaker at the evening meeting was Dale Turner, Masonite Corp., who spoke on "The Production and Handling of the Materials going into the Manufacture of Masonite Board".

The Section scheduled an annual spring meeting for May 1–2, 1958, to be held at Berkeley, Calif. Theme of the meeting will be bark utilization.

Tours, Technical Sessions Draw Over 200 Registrants at Pacific Northwest Meeting

Edge and End Gluing was the theme of the Pacific Northwest Section Meeting, attended by more than 200 members and guests, Oct. 7–8, at the Multnomah Hotel, Portland, Ore., according to P. L. Northcott, Section secretary.

The Section voted to make a second contribution of $500 to the National Building Fund. In other action, an annual meeting to be held at Corvallis, Ore., Jan. 20–21, 1958, was announced. Membership chairman Earl McCarthy reported that present membership stood at 490.

A plant tour of the B. P. Johns Furniture Co. commenced the official program and took participants from the log pond through the manufacturing processes to the finished furniture.

Guest speaker at the banquet, Wallace E. Difford, spoke on the topic "Sales Management Does Use Research". He cited a case where 225 sizes of sash and doors, which had been shipped in as many sizes of shipping units, were reduced to 11 carton sizes by a research department. In addition to applied research, he said, we need more fundamental research so that the objective of complete wood utilization can be realized. A 30-man Swedish Men's Choir entertained banquet guests with folk songs.

At the Oct. 7 technical session, G. A. McSwain, Timber Engineering Co., presented a paper on "Design, Economics and Related Properties of End and Edge Joints Commonly in Use", in which he said that he knew of no developments in sight which promised to provide satisfactory butt-joints. He discussed the details of finger-joint design and stressed the need for cutting methods to get true surfaces.

The need for competitively adequate production was stressed by Moe Cromeens, Tri-State Machine Co., in his talk on "Mechanics of End- and Edge-Gluing". Robert B. Gilbertson, The Bell Machine Co., described how the dialectric heating principle had been successfully used in a number of applications, although it was not a "cure-all". In his paper on "Electronics in End- and Edge-Gluing" he described electronic gluing as one of our first attempts at complete automation that has paid off.

Research that led to successful R. F. gluing of butt-joints of particle board to produce panels as large as 4 feet by 12 feet was described in a talk on "Edge Gluing of Particle Board", by R. J. Lewis, Weyerhaeuser Timber Co.

At the Oct. 8 technical session, M. H. Estep, American Marietta Co., read a paper on "Summary of Adhesives for Edge and End Gluing", in which he discussed both interior and exterior glues. D. C. Greeley, Coast Mills, Weyerhaeuser Sales Co., spoke on "Marketing of End and Edge Glued Products", and stated that mills have good control over thickness, poorer control over widths, and poorest control over length. He criticized the present practice that forces a buyer to accept a percentage of shorts against his desire, and suggested that edge and end gluing made it feasible to supply the customer with exactly what he wanted in length and widths. The biggest market potential, he said, lay in making wide widths and long lengths in clear lumber of a quality that would meet demands better than currently available lumber.

H. B. McKean, Potlatch Forest Inc., read a paper by himself and J. W. Smith, of the same organization, in which he described research that developed a profitable process for manufacturing 2 x 4's from 1 x 4's, and discussed the technical and marketing problems that had been overcome. In his speech on "A Continuous Method of Scarf Jointing Plywood Panels", E. R. Knokey, Diamond Lumber Co., discussed uses for plywood panels up to 150 feet in length.

The last feature of the program was a plant tour of the E. V. Prentice Co., Portland, Ore., where visitors were shown an operating display of machinery. Salesmen and engineers were on hand to explain the operation of the machines.

Co-chairmen for local arrangements were R. P. Conklin, Cascades Plywood Corp., and Elmer Matson, Pacific Northwest Forest and Range Experiment Sta. Publicity was handled by L. P. Growney, Industrial Development Engineer for Pacific Power and Light Co., and Mrs. Hazel Conklin arranged the ladies program. Section chairman Syme handled arrangements for technical session speakers.

Borden Lab Opened in South

A technical service laboratory has been opened in Fayetteville, N. C. by the Resins and Chemical Dept. of the Borden Company's Chemical Division. It is designed to provide southern customers with service on gluing problems. The laboratory will conduct continuing tests on plywood, particle board, and adhesive performance in specific construction applications. It will also evaluate new products and participate in the development of special products.

FPRS Salutes . . .

Men Contributing Time and Efforts for Furtherance of the Society and Wood Industry

OTTO C HEYER

Otto C. Heyer—As Supervising Architect for the FPRS Executive Office Building, Otto Heyer has been a consultant and given freely of his advice since inception of the building program in the spring of 1954. Otto's principal job lies in the months ahead when construction is under way.

One of the knotty problems he will deal with is the coordinating of materials as they arrive from various donors. Otto reports that, according to the construction schedule, the building should be completed in time for presentation and exhibition to the membership at the time of the 12th National Meeting in Madison. Heyer is working closely with the architectural firm that designed the building, Eason, Anthony, McKinnie and Cox.

A veteran in the housing field, Otto has been with the U. S. Forest Products Laboratory since 1936. His main concern is with housing projects, in addition to his own research. A native of Milwaukee, Heyer attended the extension division of the University of Wisconsin. In 1934 he joined the Forest Service office in Milwaukee. He has worked on design, fasteners and connections, problems in rural construction, and spent some time in packaging research. Co-author of two publications, "Wood Frame House Construction" and "Techniques of House Nailing", Otto has worked with the adult education program in Madison in connection with house construction, and has been a lecturer at the University of Wisconsin.

Laboratory to be Built for Yale School of Forestry

Construction of a $575,000 laboratory will start this January for the Yale University School of Forestry, it was announced recently. To be named the William B. Greeley Memorial Laboratory, the building will measure 100 by 164 feet and will contain laboratories for work in wood technology, forest ecology, genetics, and tree physiology.

Adjacent to the building will be a greenhouse for study of forest biology. Modern humidity rooms, constant-temperature and constant-light rooms, offices, and a wood-working shop will also be included in the laboratory, scheduled for occupancy by next September.

Mr. Greeley, for whom the laboratory will be named, was a graduate of the Yale Forestry School in 1904. He took a leading role for many years before his death in the development plans for the School and was responsible for raising a major portion of funds received by the School from 1950 to 1955.

Newly elected officers of NLMA, l. to r.: Walter M. Leuthold, Deer Park, Wash., board chairman; N. Floyd McGowin, Chapman, Ala., president; and Robert M. Ingram, Aberdeen, Wash., first vice president.

NLMA to Proceed with Proposed FPRS Educational Program

A highlight of the recent NLMA annual meeting of directors and committees, attended by more than 300 persons, Nov. 10–13, at the Shoreham Hotel, Washington, D. C., was the appropriation of $25,000 to lay the groundwork for a national wood merchandising program, which will include the preparation of sample merchandising-advertising material and a blueprint of how NLMA merchandising efforts would tie in with but not duplicate regional activities.

On the school front, the association authorized an educational guidance program to include publication of booklets on career opportunities in the forest products industries and the field of wood technology. These booklets are to be prepared in cooperation with FPRS and distributed to students and educational guidance counselors of high schools and colleges throughout the country.

New officers of NLMA are N. Floyd McGowin, president; Walter M. Leuthold, board chairman; Lawrence D. Kellogg, policy committee chairman; and Robert M. Ingram, first vice president.

Celebrated at the meeting was the silver anniversary of the Timber Engineering Co. Harry G. Uhl, retiring president of TECO, reported on the company's achievements during the past 25 years.

In other actions, NLMA directors approved participation in the Home Improvement Council campaign to spur home fix-up and remodeling; called on the Forest Industries Council, of the lumber, paper and pulpwood industries, to establish a National Forest Pest Action Committee; endorsed the World Forestry Congress in the U. S. in 1960; decided to continue publishing "Survey of Current Forest Products Research"; and decided to award four to six $500 scholarships in 1958 to outstanding forestry school graduates.

Research, Utilization Stressed by Speakers at AFA Meeting

"If this industry could intelligently spend a billion dollars in research in the next five years, there would be no need to worry about ever cutting saw timber, for you would squirt better boards out of a nozzle on an extruder than were ever sawn from a log", C. D. Dosker, Gamble Bros., stated in a speech at the recent American Forestry Assoc. Meeting. The meeting was held in Madison, Wis., in October.

Dosker discussed the necessity for research in his paper on "The Future for Management". He said that the wood industry was losing markets to the plastics and light metals industries.

"Lake States Forestry", was the subject of a paper by F. H. Kaufert, University of Minnesota. He outlined five points needed in the area for the Lake States to compete with the South and West. They are 1) increasing growth rate and improved quality; 2) full utilization of what is grown; 3) production of other products from the forests; 4) more industrial forestry; and 5) improved productivity of small holdings.

The integrated forest utilization practices of Crown Zellerbach Corp. operations in Oregon and Washington were described by E. P. Stamm. He informed the audience that the firm operates 650,000 acres of industrial timberland, and that the firm maintains six pulp and paper mills, one veneer mill, two chemical plants, and one barker-chipper installation in the area. The chemical plants product mainly products from lignin, he said. Supply for the pulp and paper plants comes mostly from the company's tree farms. The barker-chipper installation, Stamm stated, utilizes wood down to 3-inch diameters and short lengths that cannot be handled economically, nor in sufficient volume at the main pulp mill break-down plants.

A. E. Swanke, Tigerton Lumber Co., spoke on "A Lake States Sawmill Meets Utilization Problems". He described the development of his company from a short-term operation to one of long-range utilization. R. J. Seidl, Simpson Timber Co., spoke on "Better Lumber Management through Pulp and Paper Research." He described the importance of fiber-using industries in management and utilization, and the role of research in the development of utilization factors.

N. C. Short Course Announced for January

The annual Retail Building Supply Marketing Institute will be held Jan. 13–24, 1958 at N. C. State College, it was announced recently. The two-week course is sponsored by the Carolina Lumber and Building Supply Assoc. and the College's School of Forestry and Extension Division.

Discussion will center around product, business, construction, and estimating, and the program will include lectures on blueprint reading, design and construction, trade associations and publications, stores and yard arrangement and layout, and new trends.

Enrollment will be limited to 30 with an application fee of $10 and registration fee of $40. Applications should be sent to the Carolina Lumber and Building Supply Assoc., 112–114 Builders Building, Charlotte 2, N. C.

April Set for Logging Congress

The sharing of ideas and experience to gain more efficient forest management and manufacturing of forest products is the purpose of the 4th annual Northeastern Logging Congress, April 21–23, 1958, at the Mark Twain Hotel, Elmira, New York.

Nearly 500 persons are expected to hear the program, which will include a series of panel discussions by experts from government and industry. Discussion topics will include: problems of small sawmill operators, greater safety in woods operations, practical forest management, and new methods and machinery.

Fred Simmons, Northeastern Forest Experiment Station, is general program chairman. Local arrangements are being handled by Kenneth Carpenter, Cotton-Hanlon, Inc., and Harold VanAuken, an Elmira sawmill equipment dealer, is in charge of exhibits.

Teco Rafter Designs to be Shown

Nine new Teco trussed rafter designs and a suggested trussed rafter fabricating bench design will be shown at the 1958 National Assoc. of Home Builders convention in Chicago, Jan. 19–23, 1958, it was reported recently.

One of the new designs to be unveiled is a diamond trussed rafter for residential, commercial and industrial buildings, adaptable for spans from 30 feet to 50 feet, spaced two-feet on center, with upper chord roof slope of 2½ inches in 12 inches and interior ceiling slope of 1½ inches in 12 inches.

The fabricating-bench design suggestion was prepared to aid builders in setting up operations for efficient production of trussed rafters for homes and other types of light construction. Drawings are available from Timber Engineering Co., 1319 18th St., N. W., Washington 6, D. C.

Forest Timber Sales Policies Outlined by Agriculture Official

E. L. PETERSON

Policies on National Forest Timber sales were described by Assistant Agriculture Secretary Ervin L. Peterson, responsible for U. S. Forest Service operations, at the recent NLMA annual meeting in Washington, D. C.

"Forest Service timber will not be offered at distress prices below current fair market value", Peterson asserted, but on the other hand: "As long as there are operators ready to purchase National Forest timber at current fair market values, that timber will be offered for sale up to the current ability of the Forest Service to prepare timber for sale within allowable cutting limitations and to administer sales made properly."

Purposes of the Forest Service are, Peterson said, "to offer for sale the full allowable cut on each working circle, wherever there are buyers wanting the timber; to develop timber appraisal procedures and apply them so as to provide a fair market value to the government for the timber sold and an opportunity to purchasers to make a reasonable profit on their purchases."

"It is our objective", he declared, "to make our timber sales contract as specific, precise and understandable as is required for the conduct of the timber sales business."

In referring to proposals that government-owned forest land be exchanged for private forest land flooded by federal reservoir projects, Peterson stated: "Many other landowners have their properties taken for public purposes. Farmers, for example, are having their farmlands taken for public highways and for other uses. They are not compensated in kind. They are compensated in cash".

North Carolina's Governor Luther H. Hodges as he delivered the principal address at the formal dedication of the Robertson Laboratory of Pulp and Paper Technology at N. C. State College, October 25. The Laboratory, a $300,000 facility, was named after Reuben B. Robertson, Canton, N. C.

NAMES IN THE NEWS

James R. Roberts has been appointed research manager of the Celotex Corp., it was announced recently. He will be located at the Celotex Research Laboratories at Des Plaines, Ill.

J. R. ROBERTS

J. T. RICE

Three students were honored at a recent N. C. State College luncheon. **James T. Rice,** Birmingham, Ala., received a graduate fellowship from the Hardwood-Plywood Institute; **Christopher A. Tabor,** Baltimore, Md., was awarded the 1957–58 Biltmore Scholarship; and **C. A. Hart,** Norton, Va., received the Elwood L. Demmon Research Award.

C. A. TABOR

C. A. HART

Three men were named to the University of California's Forest Products Lab. technical advisory council, announced F. E. Dickinson recently. They are **Ben Benioff,** King, Benioff and Associates; **A. B. Hood,** president of the Western Pine Assoc.; and **Russell Johnson,** Union Lumber Co. Dickinson also announced the reappointment of **Eddy S. Feldman** to another term.

E. S. FELDMAN

C. A. RISHELL

Carl A. Rishell, vice president, Timber Engineering Co., received a Forestry Achievement Award presented by Penn State University on the 50th anniversary celebration of the Mont Alto Forestry Alumni Assoc., it was recently announced. The award was presented "in recognition of outstanding service to the profession and a continuing interest in the School of Forestry".

Named chairman of the Decorative Laminate Advisory Technical Comm. of the National Electrical Manufacturers Assoc., is **T. Walter Noble,** technical director of Decar Plastic Corp.

Rudard A. Jones was appointed director of the University of Illinois Small Homes Council it was recently announced. He succeeds **James T. Lendrum,** who resigned to become architecture department head at the University of Florida. Jones served as assistant director of the council since 1951.

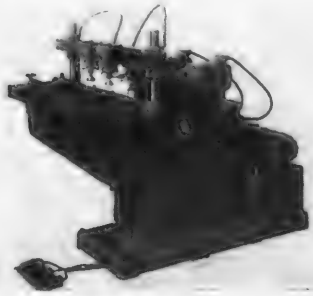
Harry G. Uhl, retiring president of the Timber Engineering Co., was honored at the recent NLMA meeting with a resolution that stated: "none has given more devotedly of his time and effort and few can match his record of accomplishments."

NEW PRODUCTS—LITERATURE

New Borer Feed System

The B. M. Root Co. has announced a change in one of its wood boring machines that is said to greatly increase its capacity for work output. The "D-170" Horizontal Radial Borer now has a hydraulic feed system which activates the radial-geared, motor-driven spindles and is controlled by foot pedal switches marked In-Out-Stop. This allows spindle motion to be started, stopped, or reversed at any point of the feed or return stroke. The stroke is adjustable from ¼ to 6 inches.

Equipped with clamping devices and an airchip blower which function with each stroke, the machine has two spindles each driven by a 1 hp, 3600 rpm motor through a geared head that is adjustable around a circle of 4-inch radius. Spindle spread is from 1 inch minimum to 30 inch maximum, and from 1 inch to 5¼ inch directly vertical. Spindle noses are regularly fitted to receive 7/16 inch to 14 thread screw shank bits. More information is available from the B. M. Root Co., York, Pa.



Hydraulic Ripping Gauge

A hydraulically operated ripping gauge has been developed by Mattison Machine Works, for use with their No. 202 Straightedging Rip Saw. The gauge is transferred to different ripping positions by large-headed pushbuttons; each pushbutton is marked with a specific ripping width.

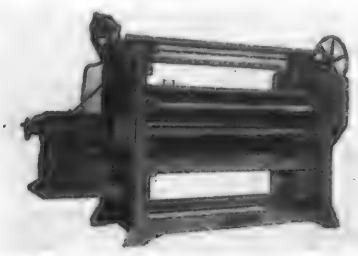
When a button is pushed, it completes one or more electric circuits, which operate through relays to actuate solenoid valves governing the functions of hydraulic cylinders. When one board is in the cut, the operator can select and push the button for the next guide position. A holding circuit will keep the guide in position until the board already in the cut clears the guide, then will move to the new position and the next board can be started into the machine.

Electric relays, hydraulic valves and cylinders to obtain correct guide settings for the particular ripping widths designated, are incorporated according to customers specifications. Each ripping width has a separate pushbutton. Further information is available from Mattison Machine Works, 545 Blackhawk Park Ave., Rockford, Ill.

New Roller Coater

A 22-D Roller Coater has been added to the equipment line of Black Brothers Co., Inc. Features of the machine are reported as patented safety control, precision ground oversize solvent resistant rolls, adjustable opening of O to 4½ inches between rolls, micrometer roll adjustments and a variety of optional extras.

Of welded steel frame, the machine utilizes box type construction and is available in 21 sizes from 8 inches through 122 inches in 6-inch increments. Descriptive literature is available from Black Bros. Co. Inc., Mendota, Ill.



See page 45-A for New Publications Listing

Diamond Jointing Stones

A line of diamond jointing stones in various sizes has been introduced by Lemmon & Snoap, manufacturers of carbide tools. Advantages are said to be smoother cuts, faster and more production between grindings. Complete details, including prices and sizes, are available from Lemmon & Snoap, 286 Bridge Street, S. W., Grand Rapids, Mich.

EMPLOYMENT SERVICE

The FPRS Employment Service is operated without charge as a service to members. Companies or institutions with positions to be filled or individuals seeking employment may participate in this program by inserting a free ad in two consecutive issues of the FOREST PRODUCTS JOURNAL. Inquiries concerning employment listings or ads to be placed in the JOURNAL should be addressed to FPRS Employment Service, P. O. Box 2010, University Station, Madison 5, Wis. Correspondence is kept confidential.

Positions Offered

E-303—Chemist or chemical engineer wanted for West Coast concern to work in product development. Several years experience in either pulp, particle board, bark conversion or finishing preferred. Firm has expanding research and development department. (Jan.)

Employment Wanted

No. 446—Position desired as research assistant in product or process development, or as industrial engineer in woodworking operation. Holds a B.S. in Forestry from N. Y. State College of Forestry. Experienced as industrial engineer in cabinet factory. Prefers New England, Northeast, or Northwest location. Age 27, married. (Dec.)

No. 448—Position desired in production with West Coast Lumber firm. 29 years of age with experience in barking, chipping, glue-up, and research and development work. Holds B.F. and B.S. degrees. (Dec.)

No. 449—Position wanted in sales, sales promotion, advertising, public relations or editorial work with company or trade publication. Holds a B.S.F. and M.S. in Forest Management. Desires salary of $5,000–$5,500. Will locate anywhere except South Atlantic States. Age 25, married. Experienced as forester. (Dec.)

No. 450—Position desired in production or sales work. Will receive M. F. degree from Yale University in January 1958. Work at Yale has been primarily in forest products and wood technology, with emphasis on plywood and laminated wood, gluing and wood properties. Twenty-eight years of age. (Jan.)

No. 451—Position desired as production manager, assistant manager, or production superintendent. Experienced as production superintendent, pilot plant development, project and process engineering, and process control in the particle board, hardboard, wood utilization and pulp industry. Holds an engineering degree. (Jan.)

No. 453—Production or management position desired by person with 15 years experience in northern hardwood plywoods, stock panels, architectural, hollow and flush doors. Experienced in synthetic resin glues, quality control, products development and buying. Good at labor relations. Holds M. F. in Forest Products. Available in January. Desires Southern plant. (Jan.)

No. 454—Management position desired. Holds Ph.D. in Forest Engineering. Has two years research experience, three years of industrial experience, and two years of commercial experience. Specialized in plywood manufacture, wall- and particle-board development, quality control, and seasoning of wood products. Age 30. (Jan.)

POSITION OFFERED

Technical man for wood fiber insulating board plant in Pacific Northwest To develop pulp and refining program and to do research work for product development. Unusual opportunity for rapid growth.

Send replies to:

E-302, Employment Service
FOREST PRODUCTS RESEARCH SOCIETY
P. O. Box 2010, University Station
Madison 5, Wisconsin

OPPORTUNITIES IN APPLIED RESEARCH

Stimulating and challenging positions are opening up in our expanding Research and Development Department in Cloquet, Minnesota. At this time there is a responsible position open in the Applied Science Area:

Research Physicist—Engineering physicist or research engineer with graduate training having background and interest applicable to fundamental mechanical properties of materials, heat transfer, moisture transfer or sound aborption and sound isolation characteristics of fibrous and porous materials. Three years industrial experience desired.

Salary commensurate with education and experience.

Applicants should submit a complete resumé of personal data, educational background, work experiences and references to:

Development Department
WOOD CONVERSION COMPANY
Cloquet, Minnesota

GUEST EDITORIAL

What's Ahead for Lumber in '58

N. FLOYD McGOWIN
President, National Lumber Manufacturers Association

N. F. McGOWIN

THE YEAR NOW DRAWING TO A CLOSE has been a sobering one for lumber manufacturers—in fact, for the entire lumber industry.

The year ahead is one to approach with cautious optimism.

It would appear that the decline in lumber output is about to end. This year's production, at this writing, is expected to total about 34 billion board feet—some nine per cent below 1956.

The prospect is that 1958 production will at least equal the level of 1957 and could very well exceed it. No more precise estimate is possible at the present time because of a number of factors which have yet to crystalize.

Housing and Tight Money

Housing is one of the uncertainties.

Tight money is expected to be the chief limiting factor to housing activity next year, as it was in 1957.

Some easing of the mortgage market is likely because of increased savings and a leveling off in the demand for funds to finance industrial plant and equipment expansion.

Still, many builders and potential home buyers will find it difficult to obtain financing.

A reasonable estimate of housing starts—both public and private—in 1958 would seem to be about one million—perhaps 1.1 million or even as many as 1.2 million, in view of the Federal Reserve Board's recent lowering of its discount rate—the fee charged on loans to member banks.

Assuming some sort of increase from this year's probable total of 950,000 to one million housing starts, it is likely that apartment units will account for a greater share of total housing ouput in 1958 than in 1957.

Merchandising Must Be Improved

How lumbermen fare in next year's housing market will depend largely upon how aggressively and how forcefully they undertake to promote the advantages of lumber and wood products to the builder, architect and prospective home buyer.

Never has there been a greater need for aggressive merchandising by the lumber industry.

The prospect of a significant increase in home remodeling-repair-expansion work next year should serve as an incentive to the industry to step up its merchandising-advertising efforts promptly.

An encouraging development of late has been the leveling off of lumber inventories at the mill level. Halting the steady rise in gross mill stocks has involved some shutdowns and, in many cases, a shorter workweek.

But the industry is in a much better position now than earlier in the year to feel the full salutary effects of a pickup in new business.

It will be no comfort to lumbermen to know that the Corps of Engineers now expects the dollar volume of its lumber purchases in 1958 to be some 25 per cent below 1957. However, military demands are subject to constant change and the increased emphasis on guided missile-space satellite developments could alter almost all procurement schedules overnight.

'58 Could be a Strengthening Year

To sum up, 1958 would seem to be a year in which the lumber industry has an opportunity to strengthen its hold on present markets and acquire new ones.

There will be many rough spots in the months ahead. But none of the problems will be of such magnitude as to defy solution by men of courage, vision and ingenuity.

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Mattison Machine Works, Rockford
Sherwin-Williams Co., Chicago
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The Dunbar Furniture Mfg. Co., Berne
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Deluxe Saw & Tool Company, Louisville
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Baker Furniture, Inc., Grand Rapids
The Dow Chemical Co., Midland
Everett Piano Co., South Haven
MINNESOTA
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Rilco Laminated Products, Inc., St. Paul
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The New Jersey Industries, Inc., New York
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Cascade Lumber Co., Yakima
Columbia Plywood Co., Inc., Seattle
Diamond Match Co., Spokane
Douglas Fir Plywood Association, Tacoma
International Paper Co., Long-Bell Division, Longview
Simpson Logging Co., Shelton
Sumner Iron Works, Everett
Weyerhaeuser Timber Co., Tacoma
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Harnischfeger Corp., Port Washington
Marathon Corp., Rothschild
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Ketchikan Spruce Mills, Ketchikan
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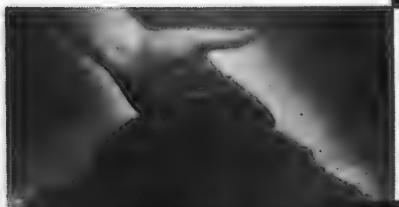

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FPRS Forest Products Journal

Vol. VII, No. 12
December, 1957

Present Status of Chemical Utilization of Lignin[1]

IRWIN A. PEARL

Senior Research Associate, The Institute of Paper Chemistry, Appleton, Wis.

The urge for more economic production has led pulp mills in many sections of the country into intensifying by-product lignin utilization programs. This paper reports modifications of old processes, and new commercial processes that have been initiated in both the sulfite and kraft pulping industries.

FOR MANY YEARS, the chemical pulping industry has been utilizing essentially only half the tree as pulp, and has been discarding the other half as a waste or as a source of heat in the recovery of soda. Pressures for the abatement of pollutional effluents, the need for conservation to meet expanding requirements for our raw materials, and the urge for more economical production in the face of higher operating costs were responsible for initiating research on the utilization of the other half of the tree.

Until the past ten years, the pollution abatement incentive was the motivating factor for most research in this field, but since then, the other two factors have been responsible for more and more of the research in by-product utilization in the pulp industry.

In an industry of constantly changing technology, pulp mills with large capital investments in particular locations have had to find revenue-producing by-products from their wastes to compete with other mills that are better situated or that employ less costly processes. Thus, many sulfite mills are turning to by-product lignin recovery and utilization to compete with kraft mills, and even some kraft mills are trying to improve their position by reclaiming values from their lignin wastes.

This paper attempts to bring up to date the story of chemical utilization of lignin from the waste products of the pulping and other wood-using industries. This subject has been covered in part by several reviews during the past few years (13, 15, 17),[2] but several recent developments have changed the lignin utilization picture in certain areas.

Lignin from the Sulfite Process

The spent liquor from the sulfite pulping process is more than 50 per cent lignin in the form of lignosulfonic acids, which are mixed with sugars and other carbohydrate decomposition products, wood extractives, and pulping chemicals. For many years, lignosulfonic acids were available commercially only in the form of the crude spent sulfite liquor. In this form, the physical properties of lignosulfonates were found useful to some extent in linoleum pastes and other adhesive compositions, binders for foundry cores, and for manufacturing ore briquets, dust laying on roads, and soil stabilization.

[2] Numbers in parentheses refer to Literature Cited at the end of this paper.

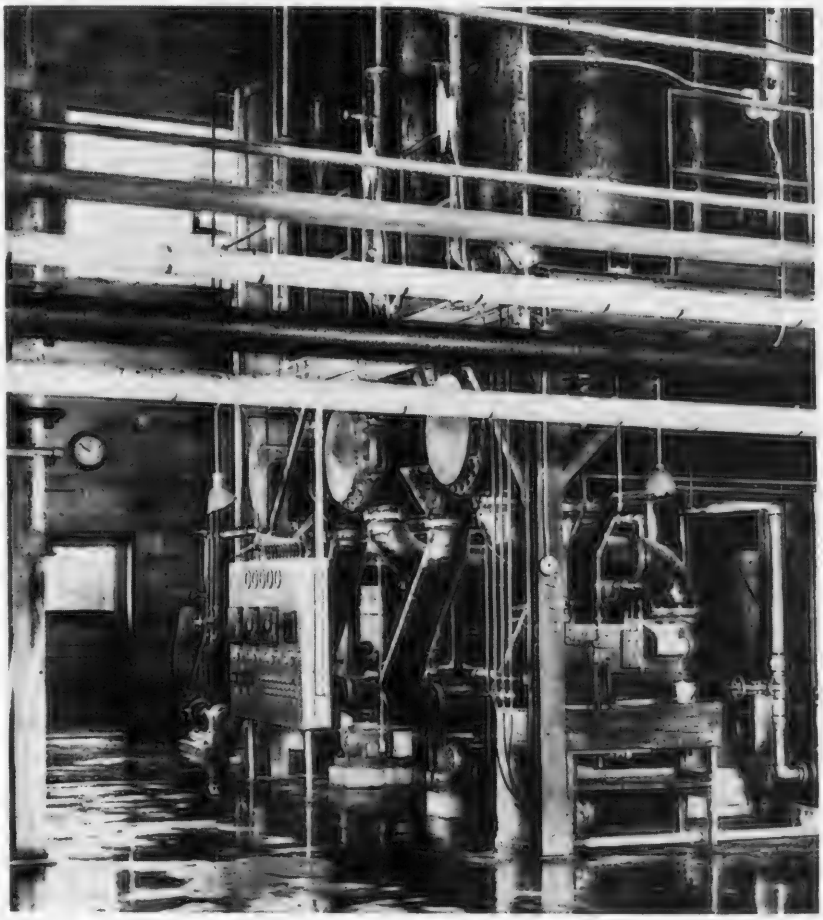


Fig. 1.—A triple-effect evaporator at the Marathon Corp. for concentrating lignosulfonates from spent sulfite liquor.

[1] Presented at Session VIII Chemical Utilization (Lignin), FPRS 11th National Meeting, June 23–28, 1956, in Buffalo, N. Y.

The Author: Irwin A. Pearl was graduated from the University of Washington with a BS degree in 1934, MS in 1935 and PhD in 1937. After serving on the Washington staff, he joined the Institute of Paper Chemistry in 1941, where he is senior research associate and chief of the lignin group.

Fig. 2.—Lignosulfonates from spent sulfite liquor make excellent emulsifiers. Photo, Crown Zellerbach.

In addition, the colloidal or surface-active properties of lignosulfonic acids in spent sulfite liquors have been utilized in the past in a number of ways. Spent sulfite liquor has been used for making emulsions for insecticidal and fungicidal purposes. Wax, resin, tar, and asphalt have been emulsified with spent liquor for road treatment. Spent sulfite liquor emulsions have been used to a considerable extent as detergents in the textile industry and as dispersions for dyeing operations.

Other emulsion uses are in lubricants and water-dispersion paints. Addition of spent sulfite liquor to Portland cement mixes increased their workability, reduced water-cement ratios, and increased the durability of the concrete. Similarly, small amounts of spent liquor materially improved the strength of magnesia bricks, ordinary bricks, and ceramic bodies.

The status of commercial availability of lignosulfonate materials changed somewhat when about twenty years ago the Marathon Corporation of Rothschild, Wis., inaugurated the Howard lime precipitation process for the isolation of basic calcium lignosulfonate from spent sulfite liquor. By this process, Marathon produced essentially carbohydrate-free lignosulfonic acid material and offered this purified lignin product to commerce in a number of forms for a variety of uses.

During the last war, the Ontario Paper Co., Ltd., of Thorold, Ont., and the Puget Sound Pulp and Timber Co. of Bellingham, Wash., began the fermentation of coniferous spent sulfite liquors to ethanol and have continued production ever since. The residual spent liquors from the ethanol fermentation are desugared to the extent of 65 to 70 per cent, and thus become another type of partially purified lignosulfonate material available for utilization.

Plants for the production of *Torula* yeast by the fermentation of spent sulfite liquor with *Torulopsis utilis* have been put in operation during the past ten years by Rhinelander Paper Co. of Rhinelander, Wis. and The Charmin Paper Products Co. of Green Bay, Wis. In this process the spent liquors are desugared to the extent of 90 to 95 per cent which leaves a lignosulfonate solution almost free of carbohydrate materials.

At the present time, two recently developed processes for producing carbohydrate-free lignosulfonate materials are being considered for commercial development. The first is a reactive solvent extraction of spent sulfite liquor solids with acid acetone to remove sugars as di–*o*–isopropylidene derivatives (6). In this process, several lignosulfonate materials of varying molecular weight are obtained as by-products. In the second process, spent sulfite liquor is fractionated into lignosulfonate and carbohydrate fractions by means of ion-exchange resins (27).

Purified lignosulfonates have found a wide variety of industrial applications. They have proven to be particularly effective in their ability to control the fluidity of oil-well drilling muds. Lime-base muds conditioned with lignosulfonates are not flocculated by contaminants normally encountered in drilling such as gypsum, anhydrite, lime, clays and salts. Furthermore, fast drilling muds containing emulsified oil can be stabilized with lignosulfonates against the adverse action of electrolytes and the jetting and churning encountered in drilling operations.

Purified lignosulfonates are exceptional dispersing agents for carbon black, and are employed in the production of black masterbatched GR–S rubber. They are used in the manufacture and application of vat dyestuffs in the textile industry, and result in speck-free, level color distribution. Wettable pesticide powders are formulated into agricultural sprays and maintained in uniform suspension during spraying by means of lignosulfonates.

Lignosulfonates are employed in industrial cleaning compositions to prevent redisposition of suspended soil and to promote free-rinsing of the cleaned surfaces. Purified lignosulfonates are used as clay deflocculants in the manufacture of brick, tile, refractories, pottery, and porcelain ware. The addition of small amounts of these agents to the slip will reduce the amount of water required to obtain any given fluidity, thereby increasing the dry strength of ceramic bodies and reducing losses due to chipping and cracking prior to firing. Since these lignosulfonate materials burn out during firing, they do not affect adversely the vitrification range of the ware.

Purified lignosulfonates have proved more effective than spent sulfite liquor as ore flotation reagents. They act as depressants for such minerals as calcite, barite, talc, sericite, molybdenite, and carbonaceous material such as graphite. In floating copper sulfides, lignosulfonates improve both grade and recovery of copper concentrates. They are also excellent dispersants for slime and are used for this purpose in both the tabling and flotation of slimy ores.

In tabling operations, they disperse the slime and prevent occlusion of ore particles. In flotation operations, the dispersing action on slimes increases the degree of separation, which results in increased recovery and grade of concentrate. This same dispersing action on slimes has accounted for improved filtration in lead-zinc operations and resulted in a reduced moisture content in the concentrate. The dispersing properties of lignosulfonates are made use of in the fluidized transportation of ores from mines to mills in pipelines. Relatively long hauls are possible without plugging.

Uses of Lignosulfonates Based on Chemical Properties: The sulfonic acid groups of lignosulfonic acids react with proteins to form insoluble complexes. This reaction is used in removing contaminating proteins from effluents of canneries or fish-processing plants and for the production of casein-lignosulfonate binders for hardboards and softboards.

Lignosulfonates have been employed to a great extent in the tanning industry. Their specific reaction with hide proteins makes them very useful as supplements to costly vegetable tanning materials such as quebracho. Although tanning with lignosulfonates alone produces inferior leathers, complementary action of lignosulfonates and vegetable or chrome tans produces leathers with qualities equal to or better than regular grades.

Pretanning with lignosulfonates conditions hide for rapid and nearly complete absorption of vegetable tans. Furthermore, hides that have been conditioned with lignosulfonates can be treated with concentrated solutions of vegetable tans without obtaining drawn grain. Sodium-base lignosulfonates are completely compatible with fat liquor emulsions, and are useful for supplying high percentages of the tannin requirement for retannage of fat-liquored and stuffed leathers.

Lignosulfonates have been found to be very effective agents for the sequestering of metallic ions, and their low cost permits their use where expensive sequestrants such as tartaric acid, sorbitol, and the like are prohibited. Complexing of lignosulfonates with certain metal ions adequately prevents

unwanted chemical reactions, precipitations, discolorations, and so forth. Ferric iron, cupric copper, and stannous tin are strongly sequestered by lignosulfonates, and cobalt, manganese, nickel, silver, stannic tin, uranium, and zinc are moderately sequestered.

The lignosulfonates are particularly well adapted for agricultural use where their sequestering action on undesirable trace elements in the soil allows growth of plants without the detrimental effect of these elements. Sensitive materials, the decomposition of which are catalyzed by the presence of traces of metallic ions, are stabilized by sequestering these ions with lignosulfonates. The sequestering action of lignosulfonates toward many metallic ions is probably responsible in part for the excellent dispersing action of the lignosulfonates in some of the applications noted earlier.

The ability of lignosulfonates to complex with metals is utilized in still another agricultural application. The lignosulfonate-iron complex has proven very successful for the control of lime-caused iron chlorosis in fruit trees. Application of lignosulfonate-iron complex in solution as a spray directly to the foliage causes greening of yellow leaves in a few days' time. The lignosulfonate complexes appear to cause less burning of leaves and fruit than do other iron chelates currently used for the same purpose.

Lignosulfonic acids and ammonium lignosulfonates react with phenol-formaldehyde resins to give low-cost condensation products with properties similar to those of the higher cost phenoplasts. They have found use as aggregate binders, binders for hardboard made by the dry process, and thermo-setting binders for laminating. It appears that lignosulfonate-phenoplast mixes will reduce the cost of binders for glass-fiber and mineral-wool insulation.

Another lignin-derived, infusible, insoluble resin from spent sulfite liquor is now being manufactured and suggested for use as filters, as surfaces for absorption of gases or dissolved particles, as catalyst supports, and as reinforcements for resins and rubber. Resins derived from spent sulfite liquor lignin contain reactive groups, and may be modified by chemical reaction under specific conditions.

Partially desulfonated sodium lignosulfonates have found use as organic agents for the internal treatment of boiler waters over a wide range of temperatures and pressures. They prevent or inhibit scale formation in boiler tubes, injectors, feed lines, and economizers by holding in suspension the carbonate and phosphate sludges formed in the reaction between water hardness and treating chemicals. Sludges do not adhere to the metal surfaces to form scale, but are kept in the boiler water where they can be blown down.

Use of Lignosulfonates as Raw Materials for Chemical Production: Although it was known for many years that vanillin could be produced in small yield by the heating of spent sulfite liquor with alkali (13, 15, 17), the need for concentrating large volumes of dilute liquors, the costly chemical consumption of the carbohydrate fraction, and the technical difficulties involved in the extraction of vanillin from the acidified reaction mixtures made the process unfeasible commercially. These difficulties were obviated by the Marathon-Howard process mentioned earlier, which yielded a lignosulfonate material free from carbohydrates and in a concentrated form.

Employing this purified lignosulfonate as a raw material, in 1937 the Salvo Chemical Corp. began the commercial manufacture of vanillin in its plants erected on the Marathon lot in Rothschild, Wis. Salvo extracted vanillin from alkaline reaction mixtures directly with butanol (25, 26), thus making acidification with ultimate loss of caustic unnecessary. This plant has continued in operation to the present time, and supplies a large percentage of the vanillin requirements of the United States. Within the last ten years, the commercial operation at Rothschild has been modified by introducing gaseous oxygen under pressure into the lignosulfonate-alkaline reaction mixture, thereby increasing the yield of vanillin (24).

An entirely different process developed by Hibbert and Tomlinson (14) was placed in operation at about the same time by Howard Smith Chemicals, Ltd., at the sulfite pulp mill in Cornwall, Ont. In this process, the whole spent sulfite liquor was treated with a large excess of caustic soda, the alkaline solution was acidified with carbon dioxide from stack gases, and was then extracted with benzene to yield vanillin.

This more costly process was possible because the caustic in the vanillin-free liquor could be regenerated by incineration and causticization in the adjacent kraft mill recovery system with incidental recovery of steam. For many years, the Howard Smith vanillin plant supplied most of Canada's vanillin requirements, and shipped substantial amounts to the United Kingdom.

After the last war, two other vanillin processes were placed in commercial operation on this continent. It is of interest to note that both of these processes employed spent liquor from the above referred to ethanol fermentation operations initiated during the war. The Ontario Paper Co., Ltd. at Thorold, Ont., began the production of vanillin from fermented spent sulfite liquor by a relatively low-cost process that used lime as the active alkali in the presence of oxygen (9–10).

At first, the sale of this vanillin was limited to the United Kingdom because of a high United States duty. The Canadian government, recognizing the importance of finding markets for products from wood waste, was successful recently in negotiating a 50 per cent reduction in the United States duty on vanillin (11). This enabled Ontario vanillin to compete in the United States market, and has resulted in the lowering of the price on vanillin.

The Monsanto Chemical Company, which for many years had been supplying approximately half the vanillin requirements of the United States with synthetic vanillin, ceased the production of synthetic vanillin about five years ago and began the production of lignin vanillin. The Monsanto plant at Seattle, Wash., utilizes concentrated ethanol-fermented spent sulfite liquor from the Puget Sound Pulp and Timber Co. mill in Bellingham, Wash. The lignosulfonate solution is converted to vanillin by a modified sodium hydroxide-oxygen treatment (7). The crude vanillin obtained in the Seattle plant is shipped to St. Louis for purification to flavoring-grade vanillin. The lignin-derived vanillin from the Seattle plant now supplies all of Monsanto's markets.

Vanillin Derivatives: The production of the fine chemical, vanillin, from spent sulfite liquor is certainly a step in the right direction in the production of valuable materials from the low-grade starting liquor. Unfortunately, flavoring vanillin requirements are so small that the amount of spent sulfite liquor or lignosulfonate utilized in its production represents only a negligible percentage of available spent sulfite liquor.

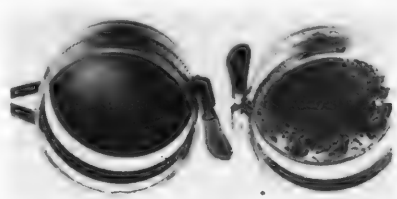


Fig. 3.—As sequestering agents, lignosulfonates find use in agricultural applications where the cost of more expensive sequestrants is prohibitive. Photo, Crown Zellerbach.

Because a study of the chemistry of vanillin and its derivatives, with the subsequent development of new chemical uses for vanillin, would stimulate chemical industry and result in the wider utilization of waste lignin, such a project was initiated a number of years ago at The Institute of Paper Chemistry. This fundamental research program was sponsored by the Sulphite Pulp Manufacturers' Research League.

Processes were found for the simple conversion of vanillin to its derived acid, vanillic acid, which heretofore had been a laboratory curiosity (16). In addition, the oxidation of lignin directly to vanillic acid was achieved in relatively high yields. Many new esters and derivatives of vanillic acid have been prepared and tested for various uses. For example, ethyl vanillate was found to be less toxic than sodium benzoate toward humans, but very toxic to specific micro-organisms. As such, it found uses as a preservative in foodstuffs and in the treatment of human diseases. At present, it is manufactured commercially for the specific treatment of the progressive disseminated form of the two mycotic diseases, histoplasmosis and coccidioidomycosis (8). The ultraviolet absorption characteristics of ethyl vanillate make it useful in sunburn preventatives, and its antimycotic properties indicate its use for tropical treatment of skin fungus infections (16).

Vanillin has been converted into hundreds of related compounds, and many of these have been evaluated for a variety of end uses. It is expected that some will soon be in commercial production. In addition to vanillin and vanillic acid, other possible organic chemicals that can be prepared from spent sulfite liquor lignin are guaiacol, acetovanillone, syringaldehyde, syringic acid, 5-carboxyvanillin, 5-carboxyvanillic acid, vanillil, and a host of other guaiacyl and syringyl compounds (20, 21, 23).

All of these products represent only a fraction of the lignin complex, however. The complete utilization of lignin in spent sulfite liquor will be obtained only after a process is evolved for the degradation of the entire lignin complex to usable guaiacyl or syringyl compounds of low molecular weight. To this end, lignin chemists in academic and industrial laboratories everywhere are applying themselves.

One recent development from the laboratories of Rayonier, Inc., of Shelton, Wash., has been the preparation of polyesters from hydroxyalkyl ethers of vanillic acid (3). In accordance with this process, vanillic acid is obtained by oxidation of vanillin or directly from lignosulfonates (16). The vanillic acid is etherified with ethylene oxide to give the hydroxyethyl ether of vanillic acid, which in turn may be esterified to its methyl ester. Condensation of the hydroxyethyl ether of vanillic acid or its methyl ester by means of heat and catalyst yields a linear polyester that can be extruded in the form of fibers or filaments, can be molded in a press, or cast from a melt. The objects so formed are similar to those polyesters prepared from terephthalic acid, and are characterized by being colorless, high melting, and resistant to the ordinary organic solvents.

At present it is reported that this process has been placed in pilot-plant operation by Japan's Kokoku Rayon and Pulp Co. on Kyushu. This plant produces a polyester fiber that is more elastic than wool, but less elastic than nylon, heavier and harder than nylon, and lighter than cotton. It is hoped that the fiber will be offered commercially by mid-1957 (2). Another similar product has just been reported (5) from protocatechuic acid, which is also prepared from lignin vanillin (16).

Hardwood Lignosulfonates: During the past ten years, several economic reasons have caused a number of sulfite mills in the Lake States to cease cooking spruce, balsam, and other conifers, and in their stead, to cook the two indigenous aspens, namely quaking aspen and bigtooth aspen. The spent sulfite liquor from the cooking of these aspens was found to be unamenable to many utilization schemes evolved over the years for coniferous spent liquors.

After considerable research on the fundamental nature of aspen spent sulfite liquor, some of these major difficulties have been overcome, and at present, hardwood lignosulfonates are competing with softwood lignosulfonates in the dispersion field. Tanning agents from aspen liquors, because of their lower molecular weight, appear to have many advantages over similar materials prepared from coniferous liquors.

The fact that aspen and other hardwood spent sulfite liquors contain lignosulfonates derived from syringyl as well as guaiacyl structural elements in the wood make these liquors unsatisfactory for the production of flavoring vanillin. Processes for the production of vanillin always yield equal or greater amounts of syringaldehyde. Analogously, vanillic acid processes yield corresponding quantities of syringic acid. Chemical utilization of these syringyl compounds and their derivatives will be achieved only after their chemistry is better established. A comprehensive program on this subject is under way at the Institute of Paper Chemistry at the present time, and results already have been reported (19).

It is interesting to note that parahydroxybenzoic acid, which is obtained directly from aspen spent sulfite liquor (18, 22), and syringic acid, which can be obtained by oxidation of aspen spent sulfite liquor lignin or syringaldehyde (16), would probably give more desirable polyester fibers than does vanillic acid because of the balanced structures of these acids.

Lignin from Alkali Processes

In the alkaline processes for producing chemical wood pulps, both kraft and soda, economics require that the organic matter in the spent liquor be burned for pulping chemical and heat recovery. In the process of recovering heat, the kraft and soda pulp mills within this country consume almost three million tons of lignin annually. Although this transformation of lignin into heat is an economic method of disposal of the spent liquor as far as the pulping operation is concerned, it seems like a wasteful manner of treating such potentially valuable chemical raw materials.

That the alkaline pulping industry is aware of this is illustrated by the fact that several soda and kraft mills in this country and Canada already are isolating and marketing both softwood and hardwood alkali lignins in commercial quantities. Research on these isolated lignins will lead to new uses for them and to larger scale participation in alkali lignin utilization on the part of the entire alkaline pulping industry.

Uses for Alkali Lignins: Alkali lignins isolated by acidification of kraft black liquors have found industrial uses very similar to those described for the lignosulfonates from spent sulfite liquors. Alkali lignins differ from lignosulfonates in that they are soluble only in alkaline solutions above a pH of approximately 9. Commercial lignins are available as water-insoluble free lignins and as water-soluble sodium salts of lignin. Alkali lignin is an excellent stabilizer for oil-in-water type slow-break asphalt emulsions where soaps are used as primary emulsifiers. It is useful as an additive to Portland cement, in which it serves to entrain air in the cement mixes and to reduce the quantity of water required to give proper flow. This lignin is an effective deflocculant and binder for clays used in ceramics, and permits a minimum of water to be used while still maintaining the desired amount of fluidity for shaping

ceramic pieces. As a ceramic binder, it imparts remarkable strength to dried but unfired bodies, thus preventing breakage at this point in the operation.

Alkali lignin is used commercially to stabilize chemical fire foams produced by the reaction of alum and sodium bicarbonate. Alkali lignin has proved very effective as a dispersing agent in the application of acetate rayon dyes, and large tonnages are used for this purpose. It has had some success as a leveling agent in the dyeing of cotton and regenerated cellulose textiles with vat and sulfur dyes. Non-tacky, odor-free, high-speed printing inks are made possible by incorporation of alkali lignin in their formulas.

Alkali lignin has found several important uses in the rubber industry. When alkali lignin is used as a dispersant for carbon black in masterbatching, it provides additional reinforcing to the co-precipitated carbon and rubber. Alkali lignin is being used commercially as an extender and modifier for latex compounds employed in making adhesives, impregnants, latex-dipped goods, and the like. It has been found that lignin can be added to latex in large percentages without causing coagulation of the rubber solids. It is applicable to natural, GR-S, nitrile, and Neoprene latices.

When co-precipitated with natural rubber or with GR-S, Neoprene, or nitrile rubbers, alkali lignin is an excellent reinforcing pigment. Because it is soluble in alkali, lignin can be added as an alkaline solution to the latex. It precipitates in very intimate admixture with the rubber upon coagulation of the latex with acid in the usual manner. In addition to good reinforcing ability, alkali lignin has the further advantages of lower specific gravity than other pigments, low hiding power, which permits better colors at high strength, and of lowering processing time on the mill.

Like the lignosulfonates, alkali lignins have commercial uses based upon their chemical as well as physical properties. Alkaline solutions of lignin are effective for removing mercaptans from petroleum distillates. Alkali lignins combine with proteins, enzymes, and other nitrogen-containing substances. The products are in general soluble in neutral and alkaline solutions, but are precipitable with acids. This property of lignin is made use of commercially in the defecation of sugar juices and in the removal of proteins from process waters so that they may be discarded into natural waterways.

Alkali lignin in a dissolved state is a cheap sequestering agent for calcium and magnesium over a narrow pH range. In systems containing fatty and rosin acids, the lignin preferentially reacts with the metal ions, thus preventing the formation of insoluble soaps. Sodium and potassium soap emulsions are thus stabilized against the harmful action of hard water or other calcium-bearing materials.

Alkali lignin has a relatively high phenolic-group content, and reacts with formaldehyde and other aldehydes to form resins. A great deal of work has been done in the resin field, but no large-scale uses for alkali lignin have as yet been developed along this line. Lignin has found some use as an extender for phenol in phenol-formaldehyde plastics and resins and paper laminates.

Alkali lignin is unique as a compounding ingredient for vinyl plastics. It can be used to increase the tear resistance of unsupported vinyl films, and at the same time give a lower cost. The lignin imparts a rich brown color and a satiny to leathery texture to the films. Efforts to produce low-priced resins of the amine or furan type have been unsuccessful.

The insolubility of alkali lignins in acidic solutions has been overcome recently by the West Virginia Pulp and Paper Co. at Charleston, S. C. This manufacturer sulfonates sugar-free alkali lignin to obtain lignosulfonic acids. Inasmuch as the sulfonation is not a function of the original pulping conditions, as in the case of the lignosulfonates in spent sulfite liquor, these synthetic lignosulfonates are offered in products with sodium sulfonate groups that comprise from 5.8 to 32.8 per cent of the products. Other sulfonate contents are available on order. The synthetic lignosulfonates from alkali lignins are useful under all the conditions found for purified lignosulfonates from spent sulfite liquor. No note has been made of their suitability in the vanillin process.

Dimethyl Sulfide From Kraft Lignin: Recently, the Crown Zellerbach Corporation, at its Camas, Wash., kraft mill, has initiated production of dimethyl sulfide from its by-product kraft lignin (11). This operation utilizes a modified Swedish process (12), in which the methoxyl groups in the kraft lignin are split off by treating the concentrated spent kraft liquor with sodium sulfide or smelt from the kraft recovery system at 250°. Although the only direct uses of dimethyl sulfide at the present time are as odorants or counter odorants in industrial gases, it is hoped that the unlimited availability of the product will increase interest on the part of the chemical industry in its use as a low-cost chemical intermediate. Some dimethyl sulfide is being used at the present time for the production of the newly developed solvent, dimethyl sulfoxide.

Lignin From Wood Saccharification

Acid hydrolysis of wood for sugar production is not practiced in this country, but it is used in Europe. The common Scholler process that employs dilute sulfuric acid at high temperatures leaves a lignin residue that is quite refractory and practically of no use commercially. On the other hand, the relatively recent plant at Rheinau, Germany, which hydrolyzes wood by a modified Bergius process that employs concentrated hydrochloric acid at low temperature, produces a reactive lignin by-product that has found a commercial outlet as a core binder for foundry use.

Conclusion

Thus, continued research on the utilization of lignin in the waste liquors of pulping processes has resulted in a variety of utilization schemes. Some of these have been placed in commercial operation by several enterprising organizations in various parts of our country. The success of these operations and their ability to lower the over-all cost of pulp production will lead to even more research and to more commercial installations of utilization processes. The intensive effort of lignin chemists the world over should lead to many great advances in the not-too-distant future.

Literature Cited

1. Anon. 1956. Chem. and Eng. News, Jan. 9; 172.
2. Anon. 1956. Chemical Week, Sept. 15; 77.
3. Bock, L. H. 1954. U. S. Patent 2,686,198.
4. Bock, L. H. 1956. U. S. Patent 2,755,273.
5. Bock, L. H., and J. K. Anderson. 1957. Paper presented before Div. of Polymer Chem., 131st Meeting of ACS, Miami, Florida, April 7–12.
6. Boggs, L. A. 1956. Isolation of crystalline sugars from softwood spent sulfite liquor via di-*o*-isopropylidene derivatives. Paper presented before Carbohydrate Div., ACS, Atlantic City, New Jersey, Sept. 16–21.
7. Bryan, C. 1954. U. S. Patent 2,692,291.
8. Christie, A., J. G. Middleton, J. C. Peterson, and D. C. McVickar. 1951. Pediatrics 7 (1):7.
9. Fisher, J. H., and H. B. Marshall. 1951. U. S. Patent 2,576,752.
10. Fisher, J. H., and C. A. Sankey. 1951. U. S. Patent 2,576,754.
11. Gralow, B. B. 1956. Chemical by-products of the paper industry. Paper Ind. 38:765.
12. Hägglund, E., and T. Enkvist. 1955. U. S. Patent 2,711,430.
13. Harris, E. E. 1955. Chemical research on the utilization of lignin. Forest Products J. 5:345.

14. Hibbert, H., and G. H. Tomlinson, Jr. 1937. U. S. Patent 2,069,185.
15. Kurschner, K. 1954. Difficulties in vanillin production from sulfite waste liquors. Faserforsch. u. Textiltech. 5: 527.
16. Pearl, I. A. 1950. Am. Perfumer & Essential Oil Review 65 (1):25.
17. Pearl, I. A. 1956. Manufacture of pure organic chemicals from chemical pulping wastes. Forest Products J. 6:505.
18. Pearl, I. A. 1957. The nature of aspen lignin. Forest Products J. 7:88.
19. Pearl, I. A. 1957. Paper presented before Div. of Organic Chem., 131st Meeting of ACS, Miami, Florida, April 7–12.
20. Pearl, I. A., and D. L. Beyer. 1954. J. Am. Chem. Soc. 76:6106.
21. Pearl, I. A., and D. L. Beyer. 1956. Tappi 34:171.
22. Pearl, I. A., and D. L. Beyer. 1957. New developments in the chemistry of lignin. Tappi 40:45.
23. Pearl, I. A., and E. E. Dickey. 1952. J. Am. Chem. Soc. 74:614.
24. Salvesen, J. R., D. L. Brink, D. G. Diddams, and R. Orozarski. 1948. U. S. Patent 2,434,626.
25. Sandborn, L. T. 1938. U. S. Patent 2,104,701.
26. Sandborn, L. T., J. R. Salvesen, and G. C. Howard. 1936. U. S. Patent 2,057,117.
27. Van Blaricom, L. E., and K. R. Gray. 1955. U. S. Patents 2,710,254 and 2,710,255.

Discussion

Carl Bordenca (Heyden Newport Chemical Corp.): What was the yield of parahydroxy benzoic acid?

Dr. Pearl: Two per cent, based on the spent sulfite liquor solids.

I. B. Douglas (University of Maine): You have commented on the combination of lignin with proteins—Does it have a similar reaction with amino acids?

W. M. Hearon (Crown Zellerbach Corp.): It does not.

P. Zenczak (Evans Products): What is different about the lignin from the Rheinau process?

Dr. Pearl: This information is not entirely available, but one reported difference is its ability to perform as an ingredient in core binders.

W. J. Day (West Virginia Pulp and Paper Co.): What is the primary difference of the process used in Germany that produces active lignin?

Dr. Pearl: It is a low temperature process.

Dr. Hearon: There is a prehydrolysis step followed by a high concentration hydrochloric acid treatment.

W. I. Lyness (Procter and Gamble): What criteria were used to establish the Rheinau hydrolysis lignin as an "active" one?

Dr. Pearl: It has so far been based on its plasticity and ability to function as a resin replacement.

Dr. Hearon: What is the source of the vanillin used by the Japanese in making their polyester resin? How are they able to compete economically with polyesters made from terephthalic acid?

Dr. Pearl: Vanillin is produced from spent sulfite liquor by air oxidation in alkaline solution with a copper catalyst. I do not know the answer to your second question.

The Lignin Dimethyl Sulfide Process[1]

W. M. HEARON

General Manager, Chemical Products Division, Crown Zellerbach Corporation, Camas, Washington

A new process based on lignin will make large quantities of dimethyl sulfide available at reasonable price. In the process, lignin in kraft pulping black liquors is reacted with inorganic sulfur compounds at elevated temperatures and pressures. The yield of crude dimethyl sulfide is about 3 per cent of the total kraft black liquor solids, which corresponds to about half the methoxyl groups present in the lignin.

THE KRAFT PROCESS for pulping wood is carried out by heating chips with a solution of sodium hydroxide and sodium sulfide. These chemicals dissolve the lignin that is removed from the cellulose pulp in the so-called "black liquor". This black liquor is concentrated in vertical evaporators to 50 per cent solids and in surface evaporators to about 65 per cent solids. It is then burned in a furnace, and the combustion of the organic material produces process steam. The inorganic chemicals are recovered as a smelt and are reused after chemical processing.

Thus the black liquor has a value in the pulping process as a source of heat and inorganic pulping chemicals. A new process, however, allows the recovery of an organic chemical, dimethyl sulfide, from the black liquor without essentially interfering with its usual use in the kraft process. This process then opens up new possibilities for additional values from kraft pulping.

Previous Methods of Preparation

Dimethyl sulfide may be made in the laboratory by a number of methods (8, 13, 14, 15, 22, 24,)[2] but none of these is of practical importance. There are two commercial methods not based on kraft black liquor that have been developed. One of these reacts methanol and hydrogen sulfide over a thoria catalyst at elevated temperatures (4, 5, 26). The other process reacts carbon bisulfide with hydrogen over an aluminum chloride catalyst (3). The latter has been used industrially in the past, but is not presently in operation. Both commercial methods suffer from the defect that their source of methyl groups is relatively expensive.

The Lignin Process

Unlike the previous commercial processes, the lignin process utilizes methyl groups that have only fuel value. These methyl groups come from the lignin in the black liquor.

The structure of lignin has not been determined, but it is reasonably well established to be a polymer made up of repeating phenyl propane units. In the case of softwoods, the benzene rings contain adjacent hydroxyl and methoxyl groups, while in hardwoods there is an additional methoxyl group on the other side of the hydroxyl in some units. These phenyl propane units have many variations in structure from unit to unit (1).

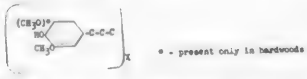
While lignin after removal by the kraft process is undoubtedly modified

[1] Presented at Session VIII, Chemical Utilization (Lignin), FPRS 11th National Meeting, June 23–28, 1956, in Buffalo, N. Y.

The Author: W. M. Hearon holds BS and MS degrees in chemistry from the University of Denver, and a PhD from the Massachusetts Institute of Technology. He was a research chemist with Eastman Kodak and an assistant professor at MIT prior to joining Crown Zellerbach.

[2] Numbers in parentheses refer to Literature Cited at the end of this paper.

from its existence in wood, it can still be considered as a polymer of phenyl propane thus:



* - present only in hardwoods

The methoxyl groups of kraft lignin are split off to a very limited degree during a kraft cook to form methyl mercaptan and dimethyl sulfide. The amounts of these chemicals, however, are very low, although sufficient to contribute to the odor generally associated with a kraft mill (12).

Hägglund and Enkvist (20) recently found that, by adding sodium sulfide to kraft black liquor and heating it to 300° C. for several hours, the amounts of methyl mercaptan and dimethyl sulfide produced were greatly increased. Based on their discovery, a process has now been worked out for making dimethyl sulfide in good yields.

This process operates on a continuous basis. Kraft black liquor of about 50 per cent solids from the vertical evaporators at 200° F. is pumped to a mixing tank, and sulfur compounds, such as kraft recovery smelt, are added about equivalent to the sulfur later to be removed as dimethyl sulfide. The mixture is heated by a heat exchanger to about 380° F. and finally by sparged steam to 450° F. This temperature is maintained until the reaction is complete by retention in a reactor tank. The tank is relieved to a flash tank, and the volatile dimethyl sulfide with water and a little methyl mecaptan is bled off through condensers. The black liquor is returned to the kraft mill for further evaporation and burning. The condensate is run to a separator tank, where the upper phase containing dimethyl sulfide is removed. This crude dimethyl sulfite is about 85 per cent pure and contains about 10 per cent methyl mercaptan and 5 per cent high boiling polysulfides. The product is purified by scrubbing with dilute caustic, drying with 50 per cent caustic, and finally distilling. The yields run about 3 per cent crude or 2.5 per cent pure, based on the black liquor solids, or 60 pounds pure per ton of pulp.

A small plant to produce 1,500,000 pounds per year has been operating on the above process at Camas, Washington, for about a year.

The product is of excellent purity and meets the following specifications:

Less than 0.01 per cent residuals
Less than 0.05 per cent methyl mercaptan
Less than 0.15 per cent water
Less than 0.2 ppm carbon disulfide

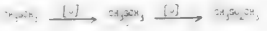
Properites of Dimethyl Sulfide

Dimethyl sulfide is a colorless liquid that boils at 37° C. (99° F.). It has a distinctive odor that is not unpleasant for the pure material. Its specific gravity at 20° C. is 0.847, and refractive index at 20° C. (D line of sodium) is 1.4349. It is essentially insoluble in water, but soluble in many organic liquids.

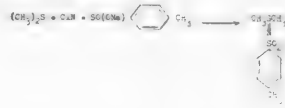
Chemical Reactions of Dimethyl Sulfide

The reactions of dimethyl sulfide are based on either the reactivity of the methyl groups or the sulfur. The methyl groups readily undergo chlorination to give mono or poly halogen compounds (29).

Mild oxidation of dimethyl sulfide produces dimethyl sulfoxide, which is now available commercially as a powerful solvent (27, 28). Further oxidation gives the sulfone (11).



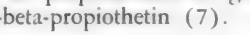
A similar oxidation with chloramine–T gives a stable intermediate.



Dimethyl sulfide forms complexes with many heavy-metal salts (6, 24, 25, 30), and halogens (21), for example:

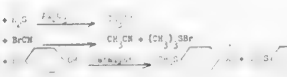
By reaction with alkyl halides, tertiary sulfonium salts are formed (8).

The same type of reaction occurs with beta propiolactone to give dimethyl-beta-propiothetin (7).



Reaction with sulfur and alkali at high temperatures forms the disulfide and polysulfides (9).

Dimethyl sulfide can also be cleaved by such reagents as hydrogen sulfide (2), cyanogen bromide (10), or phenols (23).



Uses for Dimethyl Sulfide

The distinctive odor of dimethyl sulfide makes it of value as an ingredient in ordorizing formulas for natural and artificial gas. This same property makes dimethyl sulfide of interest in industrial counter-odorant formulas. It also finds limited use as a perfume intensifier.

Because of its immiscibility with water but compatability with many organic materials, dimethyl sulfide shows promise as an industrial solvent. Its solvent properties are similar to, but somewhat better than, diethyl ether.

As a chemical, dimethyl sulfide is, of course, the raw material for making dimethyl sulfoxide. It is also an interesting raw material for plactics, and chemicals for the rubber and agricultural industries.

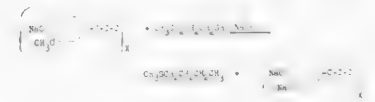
Mechanism of the Lignin—Dimethyl Sulfide Reaction

The first reaction appears to be between lignin and sulfide ion to give methyl mercaptan:

By modifying the reaction conditions, it is possible to remove the mercaptan formed at this stage before it can react further.

The second step is for the mercaptan to react with other methoxyl groups in the lignin to form dimethyl sulfide.

This step is further demonstrated to occur by reacting the kraft lignin with some other mercaptan under the conditions of the dimethyl sulfide process, and the product is then predominately the new mixed sulfide (16), thus:



The total methyl groups removed from the lignin are about half of those present. The black liquor that has been run through the dimethyl sulfide process, when rerun, does not produce further product. In other words, apperently only half the methoxyl groups in the lignin are reactive. No explanation is offered for this surprising result.

Obviously, the lignin can theoretically be from other sources than the kraft process. In practice, this has been found to be true. Lignin from the soda

process works equally well. Lignin sulfonic acid, which is produced by the sulfite pulping process, also produces dimethyl sulfide by this process. The usual sulfite waste liquor contains both lignin sulfonic acids and reducing sugars. The latter interfere with the reaction, however, and must be removed to get highest yield (19).

Going a step further, other sources of methoxyl groups besides lignin should work, and this has been found to be true. Such materials as anisole (methoxybenzene) and phenatole (ethoxybenzene) will produce the corresponding dimethyl sulfide and diethyl sulfide in this process (17). Obviously, however, lignin is the least expensive source of alkoxyl group and only methoxy is present. Therefore, the process is limited by practical considerations to the production of methyl derivatives.

Methyl Mercaptan

As stated above, by modifying the conditions of the dimethyl sulfide process, it is possible to remove the intermediate, methyl mercaptan, as it is formed. The resulting crude product is about 85 per cent mecaptan and 15 per cent dimethyl sulfide, and can give pure methyl mercaptan by fractionation (18).

Thus this process is capable of producing two basic organic chemicals, dimethyl sulfide and methyl mercaptan.

Conclusions

The production of dimethyl sulfide from lignin represents a practical method for producing this chemical on a commercial scale. The kraft industry of the United States could produce about 350,000 tons of this product per year. By modifications in the process, it can also be used to produce principally methyl mercaptan.

This process represents a pioneering break-through in the long-established problem of making pure organic chemicals for industry from lignin, nature's second most abundant organic raw material.

Literature Cited

1. Adler, E. 1957. Newer views of lignin formation. Tappi 40:294–300.
2. Beach, L. K., and A. E. Barnett. 1954. Preparation of alkyl mercaptans. U. S. Patent 2,667,515 [Chem. Abstracts 49: 367 (1955)].
3. Bell, R. T. 1951. Methyl and methylene sulfur compounds. U. S. Patent 2,565,195 [Chem. Abstracts 46:3555 (1952)].
4. Bell, R. T. 1952. Methanethiol catalyst. U. S. Patent 2,592,646 [Chem. Abstracts 46:6294 (1952)].
5. Bell, R. T. 1953. Methanethiol. U. S. Patent 2,647,151 [Chem. Abstracts 48: 7623 (1954)].
6. Blättler, G. 1920. Trimethysulfonium compounds. Monatsh. 40:417–29.
7. Blau, N. F., and C. G. Stuckwisch. 1951. A new synthesis of dimethyl-b-propiothetin hydrochloride. J. Am. Soc. 73:2355–6.
8. Bohme, H. and W. Kruse. 1949. Dialkylphenacylsulfonium salts and their scission with aqueous lyes. Chem. Ber. 82:126–32.
9. Bottger. 1884. Ann. 223:348.
10. Cahours. 1854. Ann. 90:94. See also Braun, J. V. and P. Engelbertz. 1923. Mixed organic sulfides and cyanogen bromide. Ber. 56:1573–7.
11. Douglas, T. B. 1946. Heats of formation of liquid methyl sulfoxide and crystalline methyl sulfone at 18°. J. Am. Chem. Soc. 68:1072–6.
12. Felicetta, V. F., Q. P. Peniston, and J. L. McCarthy. 1953. Determination of hydrogen sulphide, methyl mercaptan, dimethyl sulphide and disulphide in kraft pulp mill process streams. Tappi 36:425–32.
13. Ferrario, E. and H. Vinay. 1910. Action of the halogen derivatives of sulfur or magnesium organic compounds. Bull. Soc. Chim. France 7 (4):518–27.
14. Fetkenheuer, B., H. Fetkenheuer, and H. Lecus. 1927. Concerning the action of sodium amalgam upon carbon disulfide. Ber. 60:2530–6.
15. Gillis, J. 1920. Isomerization and polymerization of methyl thiocyanate. Rec. Trav. Chim. 39:330–8.
16. Goheen, D. W. 1957. U. S. Patent applied for.
17. Goheen, D. W. 1957. U. S. Patent applied for.
18. Goheen, D. W. 1957. U. S .Patent applied for.
19. Goheen, D. W., and W. M. Hearon. 1957. U. S. Patent applied for.
20. Hägglund, E. K. M., and T. U. E. Enkvist. 1955. Method of improving the yield of methyl sulfide obtained by heating waste liquor from cellulose manufacture by adding inorganic sulfides. U. S. Patent 2,711,430 [Chem. Abstracts 49:11280 (1955)].
21. Hantzsch, A., and H. Hibbert. 1907. Concerning addition products of trialkylphosphines-ansines and -stilbenes. Ber. 40:1508–19.
22. Levi, G. R. and G. Natta. 1924. Action of aluminum sulfide on some organic compounds. Gazz. Chim. Ital. 54:976–7.
23. Mavity, J. M. 1956. Aromatic thio ethers. U. S. Patent 2,745,878 [Chem. Abstracts 51:1267 (1957)].
24. McAllan, D. T., T. V. Cullum, R. G. Dean, and F. A. Fidler. 1951. The preparation and properties of sulfur compounds related to petroleum. J. Am. Chem. Soc. 73:3627–32.
25. Phillips, F. C. 1901. Compounds of methyl sulfide with halides of metals. J. Am. Chem. Soc. 23:250–8.
26. Sabatier, P. and A. Mailhe. 1910. General method for the direct preparation of mercaptans by catalysis starting with alcohols. Compt. Rend. 150:1217–21
27. Smedslund, T. H. 1952. U. S. Patent 2,581,050 [Chem. Abstracts 46:866 (1952)].
28. Tarbell, D. S., and C. Weaver. 1941. The condensation of sulfoxides with p-toluenesulfoneamide and substituted acetamides. J. Am. Chem. Soc. 63: 2939–42.
29. Truce, W. E., G. H. Birum, and E. T. McBee 1952. Chlorination of dimethyl sulfide and some of its derivatives with sulfuryl chloride and thionyl chloride. J. Am. Chem. Soc. 74:3594–9.
30. Tschugaeff, L., and W. Subbotin. 1910. Concerning isomeric platinum compounds of organic sulfides. Ber. 43: 1200.

Discussion

S. Woodruff (Battelle Memorial Institute): What will be the selling price of dimethyl sulfide?

Dr. Hearon: $0.15/lb. in tank cars

I. A. Pearl (Institute of Paper Chemistry): What is the nature of the demethylated lignin residue?

Dr. Hearon: It is still soluble in alkali and can be precipitated. However, it is darker in color than regular kraft lignin.

E. C. Jahn (State University of N. Y. College of Forestry): What effect, if any, does the dimethyl sulfide process have on the concentration of the residual liquor going to the recovery system?

Dr. Hearon: There was actually some 5 per cent increase in concentration.

A. S. Gregory (Weyerhaeuser Timber Co.): Are there any vesicant properties of the chlorinated dimethyl sulfide?

Dr. Hearon: There are none because the chlorine must be in a beta position to the sulfide linkage to have vesicant properties.

Chemical Properties, Derivatives, and Uses of Levulinic Acid[1]

CARL BORDENCA

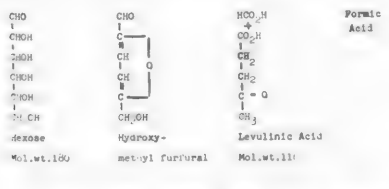
Director of Research, Heyden Newport Chemical Corp., New York, New York

Although levulinic acid has been known for 80 years, high cost and low yield have limited commercial development. These obstacles are now said to be overcome. Among the derivatives described are alpha-angelica lactone, vinyl levulinate, celluloses, levulinate acetate, dimethyl-pyrrolidone, and basic aluminum levulinate.

THE USE OF WOOD as a chemical raw material is of economic importance because its supply is immense and replenishable. Availability, however, is only one of the factors influencing such use of wood. Chemical utilization of wood can be attractive only if the wood can be obtained at a sufficiently low cost or if it can be converted in good yields to products of sufficiently high value. Conversion of spent wood from a Naval Stores operation to levulinic acid appears to fulfill these two requirements.

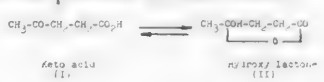
Levulinic acid was discovered in 1875 (3)[2] among the hydrolysis products of hexose sugars. Although many of its reactions and uses have been disclosed since that time, none appears to have achieved such significance as to have encouraged a sustained production on a very large scale. The limited commercial development of levulinic acid has been attributed to its high raw material cost and low yield in its production. These difficulties are overcome in the Heyden Newport process, which will be described in a future paper.

The formation of levulinic acid from wood involves the conversion of its cellulose to hexose sugars, and their subsequent dehydration and decomposition according to the following scheme (10):



Calculations based on these equations show a theoretical weight yield of 64.4 per cent from hexose. This corresponds to a weight yield of levulinic acid of 28 per cent from spent wood. In practice, yields as high as 45 per cent have been obtained from glucose (12) and a yield of 24 per cent has been reported from Douglas-fir saw dust (2). It will be noted that one mole of formic acid is obtained theoretically for each mole of levulinic acid.

Chemically, levulinic acid is a keto-valeric acid that undergoes reactions typical of organic acids and ketones. The position of the keto grouping in the acid is such that cyclization can occur, which leads to the formation of a hydroxy lactone. Spectral data confirm the presence of both forms.



As an acid, levulinic acid is of the same order of strength as acetic acid. It is stable at temperatures below 200 C., and above that temperature decomposes with the formation of alpha-angelica lactone and other products.

Salt of levulinic may be prepared by conventional techniques, and are distinguished by their solubility in aqueous or oxygenated solvents an important difference between the salts of levulinic acid and those of fatty acids in general, and has limited somewhat the range of their utility. This has been particularly true with the drier-type salts commonly used in the protective-coatings industry.

Calcium levulinate is the only salt that has achieved any commercial importance. It is used for the intravenous injection of calcium, and is advantageous in that a high concentration of calcium can be obtained in a small volume. Use of calcium levulinate appears to be declining, probably chiefly because of the lack of a commercial source of levulinic acid. It is of interest to note that, in contrast to the calcium salt of propionic acid, calcium levulinate is ineffective in preventing or inhibiting mold growth (6).

The iron salts of levulinic acid, and particularly the ferrous salt that should be of value in pharmaceutical applications, do not appear to have been described or investigated. This may be due to the difficulty of preparation or to the lack of interest because of the unavailability of levulinic acid in commercial quantities.

Interestingly, the basic aluminum salt of levulinic acid has not been previously prepared or described. It may be formed by the reaction of the proper proportions of basic aluminum acetate and levulinic acid. Basic aluminum levulinate is very soluble in water, and in sufficiently high concentrations will form gels with the alcohols and with other oxygenated solvents. It has the astringent properties characteristic of aluminum salts, but has the advantage of forming solutions with a higher pH. Suggested uses are as a gelling agent, in textile waterproofing, and for cosmetic preparations (stick-type deodorants).

A myriad of levulinic acid esters has been prepared (8). Suggested uses include those as plasticizers, flavors, hydraulic fluid components, emulsifiers and solvents. Vinyl levulinate is a new derivative of levulinic acid, not previously described. It is a colorless liquid with a mild fruity odor, boiling point of 93° at 17 mm, refractive index of 1.4388 at 29°, and density of 1.031 at 29°/29°. Vinyl levulinate is conveniently prepared by the interaction of vinyl acetate and levulinic acid in the presence of appropriate catalysts. It offers a number of interesting possibilities. It has a vinyl group for polymerization and an acid grouping with a reactive keto grouping. While vinyl levulinate does not polymerize readily alone, at least not to give high molecular weight products, it does copolymerize with a number of

[1] Presented at Session XI, Chemical Utilization (General), FPRS 11th National Meeting, June 23–28, 1957, in Buffalo, N. Y.

[2] Numbers in parenthesis refer to Literature Cited at the end of this report.

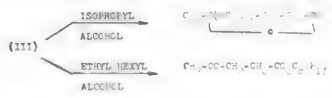
The Author: Carl Bordenca holds a BS from Howard College, an MS from Georgia Tech., and a PhD from Purdue University. Dr. Bordenca was an instructor at Alabama Polytechnic Institute, research chemist with Visking Corp., research chemist and later assistant director of Southern Research Institute, and assistant to the president, Newport Industries, before he assumed his present position.

other vinyl compounds. Copolymerization with vinyl chloride gives a product with increased tensile strength, improved heat stability, and increased dye susceptibility as compared to vinyl chloride polymerized alone. In addition, with its available keto grouping, its copolymers may be cross-linked to yield thermosetting products.

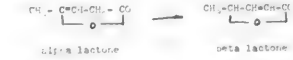
While cellulose esters of levulinic acid have been mentioned in the patent literature (11), their properties have not been defined. A series of cellulose acetate levulinate mixed esters prepared by ester interchange between cellulose acetate and levulinic acid has revealed some interesting properties. As in the vinyl polymers, the introduction of levulinyl groupings into the polymer chain gave enhanced tensile strength and increased dye susceptibility. By partial hydrolysis of a high levulinyl cellulose acetate levulinate, a cold-water-soluble product may be obtained. Tests show this product to be an emulsifying agent, and to be effective in preventing soil-redeposition on synthetic fibers such as Nylon and Dacron as well as on cotton.

As indicated above, alpha-angelica lactone may be prepared by heating levulinic acid above 200°. Better yields are obtained, however, by distilling levulinic acid slowly at low temperatures and pressures in the presence of phosphoric acid (5).

An examination of its structure reveals alpha-angelica lactone to be the anhydride of levulinic acid. Depending on conditions, however, derivatives of the acid or the lactone form can be obtained (7). For example, treatment of alpha-angelica lactone with isopropyl alcohol in the presence of acids yields the pseudo ester (derivative of the lactone form), while ethyl hexyl alcohol yields the normal levulinate ester.



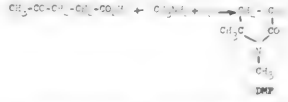
When alpha-angelica lactone is heated in the presence of amines, it is isomerized to beta-angelica lactone. An improved method for this process is now available (9).



While the alpha lactone is reconverted readily to levulinic acid by water in the presence of an acid catalyst, the beta lactone is much more stable.

Hydrogenation of both lactones proceeds readily to give gamma valerolactone, and under more drastic conditions proceeds to give 1,4-pentanediol (1). Valerolectone and beta-angelica lactone are miscible with water in all proportions, while the alpha lactone is only slightly soluble in water. Valerolactone was offered commercially for a very short time.

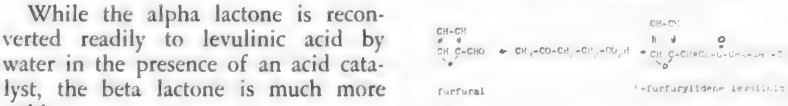
If levulinic acid is hydrogenated in the presence of ammonia or primary amines, a pyrrolidone is formed. Most interesting among these is 1,5-dimethyl, 2-pyrrolidone (DMP) obtained from methylamine and levulinic acid.



It is completely miscible with water in all proportions, and is an excellent solvent for resins and polymers. It is an excellent solvent for acetylene, and its use as a selective solvent in petroleum refining is also indicated.

Properties of the solvents from levulinic acid are summarized in Table 1.

Examination of the structure of levulinic acid reveals it also to be a methyl ketone. It undergoes the reactions that are characteristic of ketones to form oximes, semicarbazones, and hydrazones. It reacts with sodium hypoiodite to yield iodoform and succinic acid in good yields. Of particular interest is the condensation of levulinic acid with furfural to yield 5-furfurylidine levulinic acid (4).



This product is an intermediate for the preparation of 4,7-diketosebacic acid, which is of interest in making polyesters and polyamides for plastic and textile applications.

Thus it may be seen that the hydrolysis of wood to levulinic acid provides a raw material that is extremely reactive and that can be converted to compounds of potential interest in a number of fields. With the availability of levulinic acid at a suitable cost, further uses can no doubt be developed and a sizeable market for levulinic acid established.

Table 1. PROPERTIES OF SOLVENTS FROM LEVULINIC ACID

	alpha Angelica lactone	beta Angelica lactone	gamma Valero-lactone	Dimethyl-pyrroli-done
Molecular weight	98.1	98.1	100.1	113.2
Density	1.083	1.082	1.044	0.995
Freezing point, °C.	17.9	Ca. −30	Ca. −24	Below −70
Solubility in water, %	3	100	100	100
Boiling point, °C.				
10 mm.	51.8	83.1	79.8	
100 mm.	104.6	141	136.5	
400 mm.	152	185	182.3	
760 mm.	169	208	207.5	216
Specific gravity, 25/4	1.083	1.082	1.044	0.995
Refractive index, 25°	1.445	1.455	1.430	
Flash point, °F.	152	210	201	

Literature Cited

1. Christian, et al. 1947. Jour. Am. Chem Soc. 69:1961–3.
2. Frost and Kurth. 1951. Tappi 34:80–6
3. Grote and Tollens. 1875. Ann. 175 181.
4. Hayashi, et al. 1954. J. Chem. Soc Japan, Ind. Chem. 57:299–300.
5. Helberger, et al. 1949. Ann. 561:215 20.
6. Heyden Newport laboratories. Unpub lished results.
7. Langlois and Wolff. 1948. Jour. Am Chem. Soc. 70:2624–6.
8. Leonard. 1956. Ind. and Eng. Chem 48:1330–41.
9. Leonard. 1957. U. S. Patent 2,761,869
10. Pigman and Goepp. 1948. Carbohy drate Chemistry. Academic Press.
11. Staud and Webber. 1933. U. S. Paten 1,900,871.
12. Wiggins. 1950. Advances in Carbohy drate Chemistry. 4:pp 306–14

Structure and Composition of Aspen Bark[1, 2]

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and
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The general appearance, morphology, chemical composition, and pulping characteristics of aspen bark are discussed. Pulping by the soda process gives a low yield of granular residue that consists of aggomerates of stone cells and fibers. The refined residue from cooking with neutral sodium sulfite consists of bundles of fibers from the inner layer of the secondary phloem.

TREE BARKS ARE RESIDUES with relatively little use. With few exceptions, such as the small quantities of redwood, aspen, hemlock, oak, and other barks used in fiber products, tannin extraction, and so forth, barks constitute disposal problems even when they are used for fuel. They make up from 8 to 15 per cent of the total volume of timber harvested. In the case of pulpwood alone, this is equivalent to three to five million cords annually. This tremendous volume of little-used raw material poses a challenge to the forest products research worker, particularly to the wood chemist.

What is true for tree barks generally holds for the bark of aspen (*Populus tremuloides*). The use of aspen for pulpwood in the Lake States has increased annually, from less than 100,000 cords in 1936 to over 1,000,000 cords in 1956. As the volume of aspen increases, so does the volume of bark that goes unused, the volume used for fuel, or the volume that constitutes a costly disposal problem.

In comparison to the research that has been given wood, bark has been almost completely neglected—probably a reflection of its low economic value. It was recognition of this situation that several years ago stimulated the Minnesota School of Forestry to initiate studies into the characteristics, structure, composition, and improved utilization of aspen bark. This paper summarizes the results obtained from several studies of these problems.

Physical Properties of Aspen Bark

Aspen bark is notably variable in appearance from smooth and light colored to rough and dark. The normal bark is smooth and gray in color, with a powdery efflorescence, and typically waxy feel. The rough, darker colored bark is associated with abnormal periderm formation (8)[3], which apparently results from mechanical injury or attack by fungi and lichens.

The proportion of bark and its thickness as found on stems of various diameter classes is given in Table 1.

Hale (7) reported similar data in confirmation of the generalization that the thickness of bark increases with age of the tree and decreases with height of section in any given tree.

The specific gravity of aspen bark was also reported to decrease with an increase in diameter of tree, irrespective of the age of the tree.

[3] Numbers in parentheses refer to Literature Cited at the end of this paper.

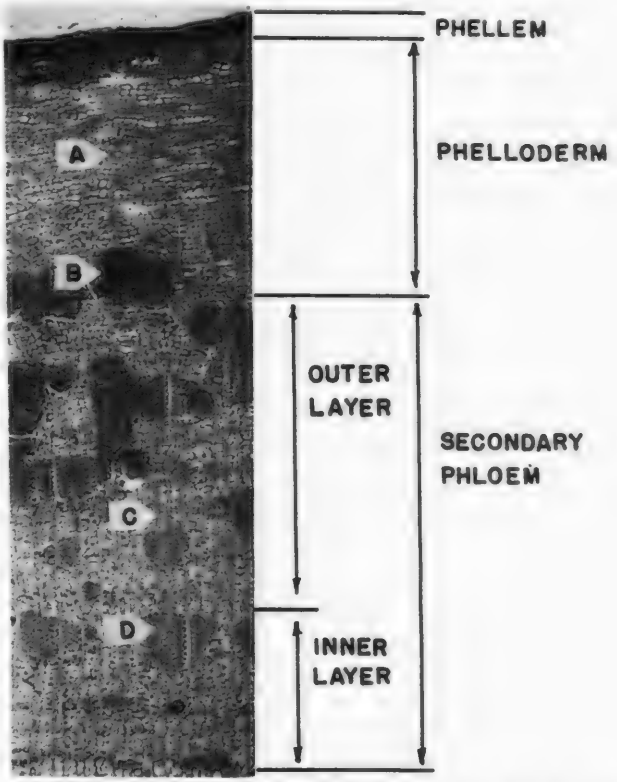

Fig. 1.—Photomicrograph of a cross section of aspen bark, showing anatomical regions. A, parenchyma cells; B, stone cells; C, ray cells; D, fibers.

[1] Presented at Session XI, Chemical Utilization (General), FPRS 11th National Meeting, June 23–28, 1957, in Buffalo, N. Y.

[2] Published as Science Journal Series Paper No. 3773 of the University of Minnesota Agricultural Experiment Station.

The Authors: Ralph Hossfeld holds a B.S. degree in chemical engineering from the University of Idaho. He also has a M.S. from Idaho and a Ph.D. from the University of Minnesota.

Frank Kaufert, president of FPRS, is a graduate of the University of Minnesota with BS, MS, and PhD degrees. He also studied one year at the University of Halle, Germany. He was associated with the U. S. Forest Service, DuPont, and the Forest Products Laboratory before joining the U. of Minn. faculty, where he is now director of the School of Forestry. Dr. Kaufert is a Fellow in the Society of American Foresters, and a former chairman of the FPRS Publications Committee.

Table 1.—WEIGHT AND THICKNESS OF ASPEN BARK AS RELATED TO TREE DIAMETER

Stem diameter Inches	Green volume 3 inch top Per cent	1.5 inch top Per cent	Average thickness Inches	Average weight in per cent of total weight of wood plus bark: Green Per cent	Over-dry Per cent
1			0.09	30.2	29.5
2			0.12	22.6	23.2
3		22.8	0.14	19.7	22.2
4	16.0	16.3	0.19	19.2	21.9
5			0.21	17.1	20.1
6	13.3	13.4	0.23	15.4	17.9
7			0.24	14.4	17.2
8	12.5	12.5	0.29	14.7	17.0
9			0.30	13.8	16.4
10			0.37	13.5	15.8
11			0.47	13.3	15.7

Table 2.—PROXIMATE ANALYSES OF ASPEN BARK *

	Present study Per cent†	Wangerin (12) Per cent	Browning (4) Fresh Per cent†	Browning (4) Seas. Per cent†	Chang (5) Per cent†
Ash	2.02	4.05			2.8
Pet. Ether	3.88				
Ether	2.07	15.13	9.6	3.4	
Benzene	0.49				4.0
Alc.-Benz.		23.52	10.8	7.3	
Alcohol	17.05		1.4	1.0	11.6
c-water		20.53			
h-water	12.89	23.06	4.1	4.9	4.7
1% NaOH					22.0
Lignin	23.01	23.86			31.2
Holocellulose		60.63			
Cross and Bevan		38.72			
Pentosan	20.30	18.54			
Pectin	7.64				
Red. Sugar‡					39.7 §

*All values are based on oven-dry weight of original bark.
†Solubilities derived from successive treatment in order as listed.
‡From hydrolysis of extractive-free bark.
§ Glucose 60 per cent, Galactose 2 per cent, Mannose 1 per cent, Arabinose 5 per cent, Xylose 30 per cent.

Aspen bark is morphologically composed of three well defined regions (6, 10). The outer layer of periderm (phellem, Fig. 1) of smooth-barked trees normally consists of from six to eight rows of more or less rectangular cells (0.029 by 0.020 mm.) and makes up about 2 per cent by weight of the dry bark. The second layer is a soft green mass of slightly tangentially elongated parenchyma cells (0.026 by 0.069 mm.) and amounts to about 17 per cent of the dry weight of the bark. This layer is considered to include the phelloderm and cortex, and may contain stone cells accompanied by small amounts of fiber. The third layer is the secondary phloem, and may represent about 80 per cent of the bark.

The bark may be easily separated into four distinct layers after a brief period of steaming in the autoclave. The first (outer) layer corresponds morphologically to the phellem and the second layer to the phelloderm. The third and fourth (inner) layers are divisions of the secondary phloem, the third layer consisting of fibers intermixed with stone cells. The fourth layer consists almost entirely of fibers (average length 0.98 mm), ray cells, and other parenchyma cells. Although sieve tubes are present in the secondary phloem, of course, they do not survive the maceration techniques employed in studying the cellular composition of the bark.

It has been found that, if the air-dry bark is coarsely pulverized in a hammer mill, it may be separated by screening or by air flotation into two fractions, one of which contains the elements of the periderm, cortex, and outer region of the secondary phloem. The other fraction is composed almost entirely of the fibrous elements of the inner bark in the form of small slivers.

Chemical Composition of Aspen Bark

The methods and results of studies of the chemical composition of a variety of barks have been summarized in reviews by Segall and Purves (11) and Kurth (9). Although the literature prior to 1946 is well represented in these publications, no reference is made to studies concerned with aspen bark. The earliest record of chemical studies of the genus *Populus* is that of Braconnot (2), who in 1830 reported the identification of the glyosides salicin and populin in the bark of *P. alba*. More recently, Browning and Bublitz (4) and Chang and Mitchell (5) have reported proximate analyses, which are summarized in Table 2 in comparison with the results of the present study.

Aspen bark is noteworthy in its high content of extractive material as reported in Table 3. Successive extraction with organic solvents and water may remove as much as 36 per cent of the original whole bark, and it is of further interest to note the distribution of these extractives within the bark. The region of phelloderm is composed of 77.5 per cent neutral extractives combined with 27 per cent of material that appears as pectin according to the method of Anderson (1). Although the summation of these analyses is greater than 100 per cent, it should be pointed out that elements of a proximate analysis are not mutually exclusive, and often represent an overlapping of components. In any event, the region of phelloderm contains only a small proportion of structural tissue.

The outer region of the secondary phloem contains the largest proportion of the bark extractives, although they are present in lesser concentration than in the phelloderm. An analysis of the alcohol-benzene extractive (3) is given in Table 4. About 75 per cent of the alcohol-benzene extractive is composed of phenolic glycosides that, according to Braconnot (2), would be represented in part by salicin (ortho hydroxymethyl phenyl -β-d-glucopyranoside) and populin (6-benzoyl salicin). The isolation in present studies of both free benzoic and salicylic acids from the crude alcohol-benzene extract supports this suggestion. The lipid fraction was reported to consist of about 50 per cent of free fatty acids with an average chain length of 14 carbon atoms. The unsaponifiable portion of the lipid material amounted to

Table 3.—DISTRIBUTION OF COMPONENTS IN ASPEN BARK

	Tissue Elements*: Phellem 2.0 Per cent		Phelloderm 17.2 Per cent		Secondary Phloem: outer layer 67.2 Per cent		inner layer 13.6 Per cent	
	layer Per cent	bark Per cent	layer Per cent	bark Per cent	layer Per cent	bark Per cent	layer Per cent	bark Per cent
Ash	8.64	0.17	2.46	0.42	1.59	1.06	2.75	0.37
Pet. Ether Ext.	13.30	0.26	14.90	2.56	1.07	0.71	2.59	0.35
Ether Ext.	2.92	0.06	3.02	0.52	1.70	1.14	2.52	0.35
Benzene Ext.	1.11	0.02	1.28	0.22	0.27	0.18	0.52	0.07
Alcohol Ext.	5.72	0.11	31.78	5.45	13.78	9.26	16.48	2.25
Hot-water Ext.	8.0	0.20	26.50	4.55	9.50	6.38	13.40	1.83
Pentosan	3.28	0.06	21.80	3.74	22.5	15.12	17.50	2.38
Pectin	0.0	0.0	27.40	4.71	3.71	2.49	3.21	0.44

*All percentages based on oven-dry weight of original bark or layer.

Table 4.—ANALYSIS OF THE ALCOHOL-BENZENE EXTRACT OF ASPEN BARK

	Per cent
Volatile substance (100° C., in vacuo)	10
Lipid substance	15
Phenolic glycoside	
Water-soluble	40
Water-insoluble	35
Nitrogen (Kjeldahl)	0.06
Phosphorous	0.05
Pentoses	Trace
Fusion temperature	75° to 85° C.

25 per cent, and was said to be composed principally of phytosterols.

As a result of present studies, it has been found that the petroleum ether extractive, represented as 3.88 per cent of the bark in Table 3, is composed in part of lignoceric acid (6.4 per cent), linoleic acid (7.7 per cent), β-sitosterol (0.2 per cent), and ceryl alcohol (0.06 per cent. An unidentified hydrocarbon (m.p. 56–7° C.) and an unidentified unsaturated β-OH-sterol have been isolated. Details of this portion of the study will be forthcoming in a later publication.

Pulping Characteristics

Although the pulping properties of aspen bark have not been extensively investigated, it has been found that the material may be disintegrated by alkaline cooking reagents, but that the pulp residue leaves much to be desired. When the bark is cooked with sodium hydroxide, the resulting screened pulp is granular; it consists of agglomerates of fiber associated with stone cells. The cellular components of the periderm and cortex, as well as parenchyma and rays, are lost in screening and the product consists almost entirely of residues from the secondary phloem. When cooked with neutral sodium sulfite, the bark retains its original form, and after mechanical disintegration and screening yields a residue of secondary phloem in a shredded and unpulped state. Microscopic examination of the screened residue shows it to consist of thin, tangential sections of the secondary phloem composed almost entirely of fiber and parenchyma cells, with the ray and stone cells removed. The yields and analyses of the resulting residues are given in Table 5.

Utilization

The yields and quality of fiber are not such as would encourage its use in any but low-grade fiber products. At present, it is being included in certain fiber products where the nature of the product does not justify removal of the bark before the wood is pulped.

The mechanical separation of the inner fibrous layer of the bark from the outer nonfibrous materials appears to have possibilities, and needs further investigation. Such separation might result in the production of a useful fiber from aspen bark.

If practical methods of recovery can be developed, the bark extractives appear to offer a possible source of chemical raw materials. The feasibility of such a method of utilization must await further information on the nature and composition of these extractives.

Literature Cited

1. Anderson, E., et al. 1937. Pectic substances from wood, II. J. Biol. Chem. 121:165.
2. Braconnot, H. 1830. Annales de chemie et physique 44:296.
3. Briggs, D. R. 1944. Unpublished research on chemical composition of aspen bark, University of Minnesota.
4. Browning, B. L., and L. O. Bublitz. 1953. Extractives of aspen wood and bark. TAPPI 36 (9):418.
5. Chang, Y., and H. L. Mitchell. 1955. Chemical composition of common North American pulpwood barks. TAPPI 38 (5):315.
6. Chang, Y. 1954. Anatomy of common North American pulpwood barks. Monograph No. 14 Technical Association of the Pulp and Paper industry. New York. p. 174.
7. Hale, J. D. 1955. Thickness and density of bark. Pulp and Paper Mag. of Canada 56 (13):3.
8. Kaufert, F. H. 1937. Factors influencing the formation of periderm in aspen. Am. J. Botany 24 (1):24.
9. Kurth, E. F. 1947. The chemical composition of barks. Chem. Rev. 40:33.
10. Shiue, C. 1957. The anatomical and physiological effects of chlorophenoxyacetic acid derivatives on trembling aspen. PhD Thesis. Univ. of Minnesota.
11. Segall, G. H., and D. B. Purves. 1946. Chemical composition of wood barks. Pulp and Paper Mag. of Canada 47 (3):149.
12. Wangerin, R. R. 1941. A chemical analysis of aspen bark. MS Thesis. University of Minnesota.

Discussion

E. C. Jahn (State University of N. Y. College of Forestry): Have you determined per cent fiber in bark?

Dr. Kaufert: Not specifically. I would guess there was about 20 to 25 per cent stiff-walled fiber.

J. L. Zeigler (Arthur D. Little, Inc.): When you pulp the entire log, does the bark present any special problems?

Dr. Kaufert: It might. For example, the dense stone cells might settle out, which would give non-uniformity. This happens in board manufacture.

Dr. Jahn: I know of one mill using alkaline pulping which pulps the entire aspen log and removes stone cells and dirt by centricleaning.

Dr. Kaufert: Perhaps Mr. Wise can tell us something about non-uniformity in board manufacture due to bark.

S. H. Wise (Wood Conversion Co.): We have found that the presence of bark increases the density of insulation board. Apparently, the bark is reduced to such a size that the bark particles lie in the interstices of the board—thereby adding weight to the board—with no increase in thickness or strength.

Clark Heritage (Consulting Engineer): Does steaming as a laboratory method of separating various layers of bark have commercial possibilities?

Dr. Kaufert: This is a laboratory technique only—using an autoclave and about 15 to 20 lbs. pressure.

Mr. Heritage: I presume you have isolated fairly large amounts of corky material from bark. What kind of properties does it have?

Dr. Kaufert: Not very promising. The material has low resilience.

Mr. Heritage: In bark from a single species, will hard tissue occur both in spherical (stone cells) and spindle form (heavy-walled fibers)?

Carl de Zeeuw (State University of N. Y. College of Forestry): Stone cells and heavy-walled fibers can occur in combination in possibly a third of the barks in U. S. trees.

Mr. Heritage: How does bark react to sodium hydroxide after extraction with water?

Dr. Kaufert: An additional 22 per cent is soluble in cold 1 per cent NaOH. Forty-two per cent of the fresh whole bark is soluble in cold 1 per cent NaOH.

F. L. Brown (Dow Chemical Co.): What kinds of aspen were used in this study?

Dr. Kaufert: Only tremuloides was used in this study. In the 1940's I worked with others.

S. A. Woodruff (Battelle Memorial Institute): What is the availability of bark? How do you get it?

Dr. Kaufert: Aspen bark is available at most pulp mills using rough or unpeeled aspen. Some is old wood when used and changed from the original or green condition. I would guess that about ¾ of the aspen pulpwood comes to the mills unpeeled.

W. I. Lyness (Proctor and Gamble Co.): What stain was used on the slide you showed of the various layers of bark?

Dr. de Zeeuw: It was probably fast green and saffranin commonly used for bark section.

Working Window Frame Parts

JOHN E. HYLER

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THERE IS A GREAT DIFFERENCE in the way window frames are handled and machined in the small shop, where it is necessary to get out two or three special frames, as against production of standard window frames in large quantities. This being true, it is not possible to make window frames in the small shop (by methods sometimes used on three or four detail frames) with sufficient economy to anywhere near compete with large stock mills that make these items. Just as sash and windows have standard sizes based on even-inch glass sizes, the same is true of standard window frames.

As time goes on, a somewhat larger portion of windows seem to be of the casement type. Regardless of that fact, the double-hung window is still widely employed, and frames for double-hung windows are standard items with many large manufacturers.

There are different aspects of window-frame design, for some of which a decided advantage is claimed by their manufacturers. An instance in point is making window frames with jamb widths the same as standard 2 by 4 studding, with the exception of about 1/16-inch overwidth allowance to compensate for slight variations. Manufacturers of such frames groove the inside edge of the jamb in many cases, to receive a tongued jam liner. Under such an arrangement, jamb liners of different widths can be employed (which simply form an extension of the jamb width on which the joint is covered by the inside stop) to make the frames fit walls of varying thicknesses without any additional working.

Working Sills on Handfeed Jointer

One interesting aspect of work around small custom mills in the old days was on detail frame jobs, where it seemed architects vied with one another in incorporating frame sills of different cross section. Generally, these were worked out at a handfeed jointer, whenever there was not enough of them to justify setting up a molder for the purpose.

Considerable manipulation and several jointer setups are necessary to get out some of the types of sills that were made. The work is really not difficult, however, once a man understands the principles involved. Nevertheless, such work is encountered less and less, for in an increasing number of cases builders are realizing great economies involved by planning houses in such manner that standard frames can be used throughout.

Another change that has been quite extensive is gradual disappearance of the old weight-and-pulley system formerly employed. In the old days, many machines were found in different mills which had been specially designed for working out the special types of slotted openings required to receive the pulley hardware, and to cut the corresponding jamb pockets near the bottom of the frame. Development of different types of sash balances that took the place of the old weights made a great difference in this respect. Such machines are therefore found with less frequency.

Methods of Cross Working Frame Parts

So far as cross-working frame parts was concerned, in the old detail mill this job was often performed at a combination roller-type cutoff saw and ripsaw. On these machines, the various frame parts were sized to width, the cross-gaining was performed on the frame stiles, longitudinal grooving was machined for the parting stops, and the sills were horned.

Even in plants where window-frame work is handled in large-production quantities, there has been considerable change in the picture to greatly enhance the production rate. The leading factor in large-quantity cross-working of window-frame parts is the double-end tenoner. On modern machines of this kind, cross-working of window-frame stiles is stepped up greatly through the use of a window-frame attachment. This unit allows angle gains of from 5 to 16 degrees departure from square to be cut on the sill end of window-frame stiles, while the work feeds through the tenoner on parallel dogs.

Fig. 1.—Double-end tenoner used in the factory frame department of Long-Bell Lumber Co., Longview, Wash., for cross-working window-frame parts. This machine can handle pieces 24 feet in length. Photo courtesy Long-Bell Lumber Co., and Greenlee Bros. & Co.

This attachment automatically moves the top and bottom tenoning units at one end of the machine diagonally across the work. One can thereby trim both ends of window-frame stiles square, and make angular dado cuts at one side of the machine. The pieces are fed in pairs, back to back, so similar dado cuts are obtained in both stiles at one end, with the top and bottom tenoner heads.

It is not necessary to cut this end of the window frame stile off at an angle, parallel to the angular gain. It is possible, however, by using combination heads that dado and cut off simultaneously. A machine with such an attachment can readily have it disconnected when one is through with this particular job, which allows the tenoning heads to be returned to normal position for other work.

Horning Window Frame Sills

On machines of this kind, notching corners of workpieces passing through the tenoner while they are held on edge is a not-unusual job. In producing notches necessary in the window-sill horning job, however, a special problem arises. It is necessary to hold the sills at an angle that corresponds to the amount of their "pitch" and to the bevels that have previously been machined on their edges. This is accomplished by using special clamp dogs to hold the sills at the correct angle for trimming and notching.

On double-end tenoners, sills up to 7½ inches in width can be handled on units with 60-inch beams. Notching saws, mounted on the tenoning and coping units, will cut as deep as 5¼ inches from below, and up to 4⅝ inches inward from the end of the piece. Usually, it is best to have extended cutoff saw mountings and longer tenoning or cope spindles where this job is performed, depending on the length of horn required on the sills.

Some Physical Factors Influencing the Effectiveness of Preservatives[1]

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Decay tests indicate that effectiveness of pentachlorophenol against a typical brown rot is independent of the swelling capacity of the solvent over a wide range. With white rot, the results indicate increased efficiency of the fungicide when deposited from the better wood-swelling solvent. Data were evaluated by application of the logistic function.

AT THE OTTAWA LABORATORY of the Forest Products Laboratories of Canada, a study is being made of some physical factors that may influence the effectiveness of preservatives. This work has involved the study of some oil-type preservatives as well as solid fungicides deposited in the wood. The preliminary work connected with the latter type of preservative is reported here, and as the continuing work is completed, it also will be reported.

The effectiveness of the treatment of wood with a solid preservative, present alone in the wood after the evaporation of the vehicle, was investigated with the view that the vehicle might influence the effectiveness of the treatment. It was felt that any influence of the vehicle on the effectiveness of the treatment might be related to its wood-swelling capacity, since this property modifies the location of a deposited substance. Liquids that do not swell wood, such as light fractions of petroleum, are found to leave dissolved substances, such as water-repellant resins, on the capillary surfaces of the wood (9)[3]. Liquids that swell wood, however, are found to expand the cell wall and induce the penetration and deposition of solids in this region. This is illustrated by the process of "bulking" wood to reduce dimensional change, in which solid matter is deposited in the cell wall through the use of wood-swelling solvents (10).

In industrial preservative treatments that involve the deposition of pentachlorophenol in the wood, light petroleum fractions are employed as the solvents. In such treatments, it would be expected that the preservative is deposited in the capillary surfaces and not within the cell wall. To investigate, then, any change in effectiveness of the pentachlorophenol as its location with respect to the cell wall was modified, it was necessary to use solvents of a range of wood-swelling capacities. These solvents, together with their relative swelling capacities, are listed in Table 1.

Table 1.—THE SWELLING CAPACITY OF THE "PENTA" SOLVENTS USED

Solvent	Relative swelling capacity (water = 100) (11
Benzene	0
Toluene	1.6
n-Butyl alcohol	13.5
n-Propyl alcohol	45
Ethyl alcohol	83
Cellosolve*	87

*Ethylene glycol monoethyl ether.

Sets of test blocks were impregnated with graded retentions of pentachlorophenol by means of the solvents shown in Table 1. These sets of blocks were then subjected to a decay test to evaluate the effectiveness of each treatment. Two fungi were employed in the decay testing, the brown rot fungus, *Lenzites trabea*, and the white rot fungus, *Polyporus abietinus*. It was thought that the white rot, *P. abietinus* (2), might be inhibited in its attack on the lignin deep in the cell wall by the presence of fungicide within the cell wall; such inhibition might be expected in the series of blocks treated with the wood-swelling solvent. The brown rot, *L. trabea*, however, attacks the cellulose that is situated, for the most part, near the surface of the cell wall; it is expected that the fungicide placed within the cell wall by the wood-swelling solvent would have less effect on the action of this fungus. The results reported here appear to be consistent with this picture, but further work is being done to see if the results remain consistent for different fungi and solvents.

The first part of this investigation consists of experiments to establish the influence of the swelling power of a solvent on the distribution of the pentachlorophenol inside the wood structure. Since the cells of wood form a capillary structure, a solution of pentachlorophenol in a non-swelling solvent would only fill the capillaries and, upon evaporation, leave the capillaries coated with the residual pentachlorophenol. Subsequent leaching with a non-swelling solvent might be expected to remove practically all the deposit. A solution of pentachlorophenol in a strong swelling solvent not only brings the pentachlorophenol into the capillaries, but carries it further into the swollen (and thereby opened) cell wall. Upon evaporation, only the part of the pentachlorophenol deposited in the capillaries might be expected to be accessible to leaching with a non-swelling solvent.

Results and Discussion

Deposition of Pentachorophenol in the Cell Wall: The pentachlorophenol was of the purest grade obtainable from Eastman Kodak. The solvents were of the C. P. grade, except ethanol, which was the ordinary 95 per cent solvent grade.

Wood meal, rather than blocks, was used to promote the ease of extraction of pentachlorophenol. The wood meal, red pine sapwood, was ground in a Wiley mill and impregnated with pentachlorophenol by soaking a two-gram sample in a "penta" solution, then filtering the meal from the solution and allowing it to air-dry for one week. The weight of solution retained by the wood was in the neighborhood of three grams for each one-gram sample of meal, but was not recorded exactly since it was desired to find the amount of "penta" that entered the cell wall and not the total amount of "penta" in the wood. The "penta" solvents were: benzene, a non-swelling liquid; n-propyl alcohol, a medium-swelling liquid; and ethyl alcohol, a liquid of fairly great wood-swelling capacity.

The samples of meal were then successively extracted with benzene and alcohol, and the extracting liquid was analyzed for pentachlorophenol. The analysis was done by titrating an alcoholic solution of pentachlorophenol with aqueous sodium hydroxide to the phenolphthalein end-point. The pentachlorophenol solutions obtained by alcohol extractions were, then, ready for analysis, after being evaporated to decrease their bulk. The benzene solu-

[1] Presented at the Annual Meeting of the Eastern Canadian section, FPRS, held in Montreal on March 7–8, 1957.

[2] A contribution from the Forest Products Laboratories of Canada, a division of the Forestry Branch, Department of Northern Affairs and National Resources.

[3] Numbers in parentheses refer to Literature Cited at the end of this report.

tions were evaporated to a small volume and then bulked with alcohol.

It may be seen in Table 2 that more pentachlorophenol was found to be extractible with alcohol from the series initially treated with an alcoholic solution of the fungicide than from series in which the poorer swelling liquids, benzene and propanol, were employed as the vehicles. The amount of pentachlorophenol extracted by ethanol, however, was found to be much smaller than the quantity that the cell wall could be expected to take up.

Table 2.—EXTRACTIONS OF "PENTA" FROM GROUND SAPWOOD (1 GM. SAMPLES)

Initial penta vehicle	Penta conc. in treating solution Per cent	Successively extracted penta	
		Benzene mg.	Alcohol mg.
Benzene	0.02	1.5	
	0.04	2.3	
	0.15	4.3	
	0.50	18	
	1.00	35	
	2.00	63	2
	5.00	150	3
Alcohol	0.02	2.9	
	0.15	4.9	
	0.50	16	
	1.00	19	1
	2.00	53	20
	5.00	160	14
n-Propanol	0.02	2.2	
	0.04	3.9	
	0.50	15	
	1.00	32	
	2.00	56	
	5.00	140	3

To arrive at the expected quantity of pentachlorophenol, it is useful to consider what occurs as the solvent evaporates from a solution that fills the void spaces of the wood. As the solvent evaporates, the solution becomes more concentrated, and progressively greater diffusion into the cell wall becomes possible. This concentration reaches a maximum when the remaining solvent becomes saturated with solute. If it is assumed that the solute is carried into the cell wall at this same concentration, then the maximum amount of solid carried to that location would depend on the swelling power of the solvent for wood, and would be (in gm. solute/gm. wood):

S F d W

where S is the relative swelling power of the solvent with respect to water,

F is the fiber saturation point of the wood for water (in gm. water/gm. wood),

d is the density of the solvent,

W is the saturated weight ratio solute/solvent, and

A limit, of course, to the above uptake of solute by the cell wall is set by the void volume of the wood as well as the saturation solubility of the solute. This is dVW, where V is the void volume of the wood in cc per gram, and d and W have their previous significance.

Applying this relationship to alcohol and taking a "penta" solvency of about 50 per cent (6), it is found that the maximum uptake[1] of "penta" would be about 100 mg./gm. It may be seen in Table 2 that uptakes of 20 and 14 mg./gm. of wood are reached, but only at the higher concentrations. It can be assumed that, at the lower concentrations, some "penta" was also in the cell wall but in very small amounts. The inability of the cell wall to take up more pentachlorophenol must mean that the solute does not enter the cell wall in the same ratio as it is present in the free liquid. For solutes that themselves do not swell wood this is to be expected, because some of the solvent is bound to the swollen wood, and being associated with the wood components is not available to the solute. It is also expected that solutes of great solubility will not enter the cell wall in the proportion given above, since the swelling capacity is given for the pure solvent and not for the solution.

The n-propanol solutions induced no more penetration of the cell wall than did benzene, the non-swelling liquid. It is not certain, however, whether small amounts of "penta" are not present, since the method of analysis for amounts of "penta" in the milligram range is uncertain. This is being investigated further by a more sensitive method of analysis, in which pentachlorophenol that is tagged with radioactive chlorine-36 is used as a tracer.

The Decay Tests: The decay tests were of the buried-block type; that is, the blocks were buried in sterile soil, in jars, except for one corner that projected about ¼ inch above the soil. The jars were then sterilized, and the contents were inoculated with the test fungus. Decay was allowed to proceed for two months, then the blocks were removed, dried, and weighed, and the weight loss was recorded. The weight loss was found from the difference between the oven-dry weights of the blocks before and after decay, rather than from the weights of the blocks conditioned at some particular moisture content.

The buried-block modification of the soil-block test (8) was used, rather than the more usual soil-block test originated by Flerov and Popov (5) and developed and described by others (4, 7), in which the test-block is unburied. The buried-block test was employed because of the short decay time of about two months, compared to the four months required for the completion of the unburied-block test. Although this latter test has been proposed as an ASTM Standard (1), the buried-block test, which involves a much shorter incubation time, was considered to be suitable for the comparison of the results obtained in this group of tests.

The test blocks, which were 2 cm. cubes of red pine sapwood, were oven-dried (at 105° C.) and weighed, then vacuum-impregnated with a pentachlorophenol solution. With each solvent used, a series of about twenty blocks was prepared with a retention of pentachlorophenol graded from 0.001 to 0.1 pound per cubic foot.

Table 3.—RESULTS OF BURIED-BLOCK TESTS, WITH *L. TRABEA*[*]

Solvent	Benzene		n-Butanol	
	"Penta" retention lb./cu. ft. x10³	Weight loss per cent	"Penta" retention lb./cu. ft. x10³	Weight loss per cent
	4.21	95.2	3.97	99.7
	4.32	99.9	3.82	92.1
	8.14	90.6	7.70	89.5
	8.93	96.0	7.98	85.8
	17.1	91.7	12.2	93.3
	17.7	80.2	12.2	83.3
	20.2	79.5	15.7	89.3
	21.3	81.1	15.8	90.4
	25.2	69.6	20.8	53.7
	24.7	69.9	19.2	50.1
	28.2	41.0	23.1	75.5
	27.1	47.9	23.6	81.4
	29.1	54.3	28.0	49.3
	30.9	50.5	27.1	58.6
	34.6	34.4	30.3	5.6
	34.4	28.4	32.8	3.9
	49.6	24.5	47.7	9.2
	49.6	28.4	44.9	13.3
	66.6	5.4	64.5	7.1
	63.0	5.0	64.7	7.6
	83.1	3.4	82.2	7.1
	85.1	5.0	77.7	11.3
Solvent	n-Propanol		Ethanol	
	1.55	83.9	1.85	99.1
	1.56	94.1	4.78	98.3
	3.93	71.3	4.65	98.1
	4.09	71.6	9.33	93.3
	8.11	98.9	8.92	91.3
	12.7	87.8	13.1	78.3
	12.5	89.8	13.7	68.8
	16.0	71.8	18.4	81.9
	17.4	63.9	18.9	89.5
	19.1	95.2	23.2	49.9
	19.7	57.2	23.1	41.6
	23.0	50.7	27.7	34.9
	23.9	46.4	27.7	37.3
	29.1	44.7	32.2	49.9
	27.2	54.9	32.9	45.2
	31.8	70.4	34.5	23.1
	30.5	71.6	36.2	20.9
	49.5	20.8	54.0	3.6
	45.8	21.7	54.8	5.7
	61.9	12.3	69.0	5.5
	63.6	12.3	75.0	3.1
	78.1	5.6	86.7	4.1
	76.6	3.1	91.2	6.1
Solvent	Cellosolve		Toluene	
	1.95	75.1	1.65	95.6
	1.67	90.4	1.47	89.5
	4.60	99.5	4.14	99.3
	9.13	96.6	8.54	94.1
	8.78	92.9	8.62	79.7
	13.0	87.8	12.5	67.5
	12.9	83.5	12.6	69.0
	16.6	70.1	16.9	71.2
	16.7	70.0	17.1	83.3
	25.2	54.9	20.1	50.3
	28.6	43.9	21.4	44.8
	35.8	68.1	25.3	37.1
	35.5	63.0	24.6	36.7
	67.9	1.2	30.2	47.4
	62.7	4.2	27.4	38.9
	90.4	3.6	33.3	23.7
	80.5	1.1	32.0	27.0
			48.1	10.7
			39.1	11.3
			71.2	7.6
			68.1	6.1
			84.5	3.6
			79.0	4.2

[1] The limit, dVW, does not apply here, since the meal retains more impregnating liquid than does whole wood.

[*] The weight loss of the impregnated block is expressed as the percentage of the mean weight loss of the controls.

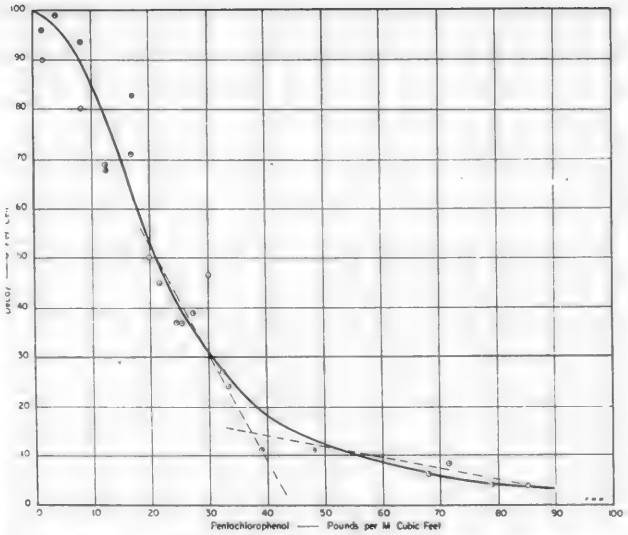

Fig. 1.—Decay of red pine sapwood blocks, treated with pentachlorophenol in toluene and exposed to *L. trabea*.

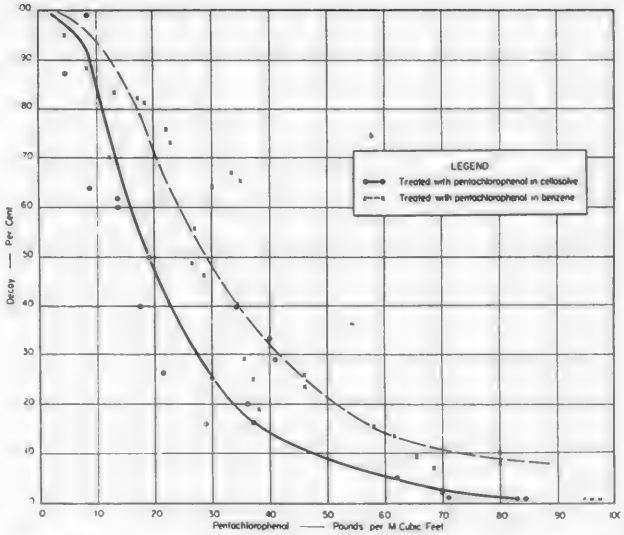
LEGEND
Treated with pentachlorophenol in cellosolve
Treated with pentachlorophenol in benzene
Decay — Per Cent
Pentachlorophenol —— Pounds per M Cubic Feet

Fig. 2.—Decay of red pine sapwood blocks exposed to *P. abietinus*.

Four extra blocks for each series were impregnated with the pure solvent and kept as controls. The excess solution was wiped from the impregnated blocks, which were then reweighed and allowed to air-dry for seven days. The retention of pentachlorophenol was calculated from the gain in weight of the freshly impregnated blocks and the concentration of the treating solution.

The pentachlorophenol and alcohol were of the same grade already mentioned. The solvents used, that is, the benzene, toluene, n-butanol, and n-propanol, were of C. P. grade.

The results of the soil-block tests are given in Table 3 for the *L. trabea* series and Table 4 for the *P. abietinus* series. The weight loss of each block is expressed as the percentage of the mean weight loss of the controls. This method of expressing the results was chosen so that the results could be used directly in subsequent calculations. Representative results are plotted in Figs. 1 and 2. The plot in Fig. 1 is of the toluene series decayed by *L. trabea*, and in Fig. 2 both series decayed by *P. abietinus* are shown.

Table 4.—RESULTS OF BURIED-BLOCK TESTS, WITH *POLYPOROUS ABIETINUS**

Solvent	Benzene		Cellosolve	
	"Penta" retained lb./cu. ft. x10³	Weight loss per cent	"Penta" retained lb./cu. ft. x10³	Weight loss per cent
	4.32	94.82	4.31	52.20
	8.40	86.59	4.29	86.15
	8.72	97.86	8.92	63.64
	11.82	69.58	8.48	98.50
	12.5	82.36	13.5	60.16
	16.65	81.36	13.8	62.38
	17.95	80.45	17.2	39.62
	21.8	75.39	19.4	50.14
	22.5	82.58	21.5	25.87
	26.3	48.05	30.3	25.23
	26.75	56.19	29.2	15.94
	28.0	45.89	36.8	17.22
	30.1	64.23	36.0	19.60
	34.9	65.43	34.4	39.91
	32.9	67.19	40.6	28.63
	34.3	40.44	39.7	33.84
	35.0	29.15	44.7	31.33
	37.5	17.62	61.7	5.34
	36.8	24.65	69.1	2.26
	43.1	25.71	70.5	1.74
	43.0	22.71	83.8	1.17
	60.7	13.04	83.4	1.23
	58.3	15.07		
	68.4	6.24		
	65.0	9.08		
	80.4	9.98		
	80.2	7.90		

* The weight loss of the impregnated block is expressed as the percentage of the mean weight loss of the controls.

The plotted results of the buried-block tests exhibit the sigmoid shape common to this type of test. That is, the effect of an increase in the dose is small at low retentions, larger at intermediate retentions, and small again at the highest retentions. The rapid change in effectiveness of the fungicide as the retention passes from the intermediate to the high values (about 40 x 10^{-3} lb./cu. ft. in Fig. 1) provides the basis for finding the threshold value, the point most often used in the comparison of wood preservatives (3). This value is found at the intersection of the dotted lines in Fig. 1, which were drawn through the approximately straight-line portions of the curve.

The threshold-value method of comparison of results was not used for the data in this paper, however. Another method, which will be described in detail in a subsequent paper, was used. This method, which is in general use for the testing of biologically active substances, involves fitting the logistic function, whose form is shown in Table 5, to the whole set of results rather than fitting two straight lines to the results in two separate regions. This change in procedure was made so that the results could be considered as a unit.

There are also certain differences, which will be discussed in a subsequent paper, between the physical state of the preservative used here and the preservatives for which threshold values are most often determined, which make the use of the logistic method desirable. If the preservative is water-soluble or carried in oil, it can be lost from the test blocks by diffusion or flow, thereby giving rise to "operational losses", which themselves cause a change in weight of the block. Adjustment is made for those operational losses by the horizontal, straight line of the threshold method. In the system considered here, however, the pentachlorophenol is not dissolved in a carrier, and so cannot flow from the blocks and it cannot diffuse from the blocks since it is not soluble in water. The "operational losses" are, then, considerably reduced and no adjustment for them need be made.

The logistic function was fitted to the data by plotting $\ln \frac{q}{1-q}$ vs. $\log x$ to give a straight line, where q and x are, respectively, the per cent weight loss of the test block and the retention of pentachlorophenol. The least squares line was calculated, and the constants thus found are listed in Table 5. The regression coefficients, which seem to indicate a good fit, are also shown. The complete sets of data were used in the calculation of the curve-constants except for a few results below a retention of about 6.3 x 10^{-3} lb./cu. ft. that were excessively scattered. Since the threshold value was not used, the sets of results were compared by calculating the dose necessary to reduce decay to 50, 27, and 12 per cent of that of the controls. These values are listed in Table 6.

It may be seen that there is close agreement, among the various series, of the amount of pentachlorophenol necessary to inhibit decay caused by

Table 5.—LOGISTIC FUNCTION CONSTANTS FOR THE SETS OF DATA *

Solvent	a	b	r (regression coefficient)
L. trabea series			
Benzene	4.435	6.462	0.96
Toluene	1.956	5.264	0.96
n-Butanol	−3.621	6.151	0.95
n-Porpanol	−4.569	6.530	0.93
Ethanol	−3.489	6.147	0.95
Cellosolve	−4.678	6.911	0.94
P. abietinus series			
Benzene	2.904	5.438	0.92
Cellosolve	2.782	6.024	0.90

*The function is $5 + 1n \frac{q}{1-q} = a - b \log x$

where q is the weight loss of a block expressed as the per cent of the weight loss of the control blocks, and
x is the dose of preservative in lb./cu. ft.
Note that, for the constants as given here, the dose was multiplied by 10^3 before being substituted in the equation.

Table 6.—"PENTA" DOSE NECESSARY TO REDUCE DECAY TO VARIOUS LEVELS

Solvent	Dose* (lb./cu. ft. x 10^3) necessary to inhibit decay to level shown		
L. trabea series	50 per cent	27 per cent	12 per cent
Benzene	28.8	41.2	49.2
Toluene	21.0	32.5	50.3
n-Butanol	25.2	36.6	53.3
n-Propanol	29.2	41.5	59.2
Ethanol	24.0	35.0	50.8
Cellosolve	25.1	35.1	49.0
P. abietinus series			
Benzene	28.4	43.4	66.3
Cellosolve	19.6	28.7	42.1

*The dose is given in lb./cu. ft., but multiplied by 10^3 for convenience.

the brown rot fungus *L. trabea*. With the white rot fungus *P. abietinus* as the decay-causing organism, however, it may be seen from Table 3 and Fig. 2 that the pentachlorophenol was more effective when placed in wood from cellulose than from benzene. Only two thirds as much pentachlorophenol was required with cellosolve as with benzene. In the *L. trabea* series there are variations in doses at the 50 per cent decay level almost as great as that between the two *P. abietinus* series, but it can be seen that the values of the doses have approached each other at the 12 per cent level for *L. trabea,* whereas the *P. abietinus* series maintain their relative difference at all levels.

This behavior agrees with the tentative picture of influence of the solvent on the action of a fungicide that was given in the introduction; that is, that the effectiveness of a fungicide might change when deposited from vehicles of different wood-swelling capacity and that the change might not be the same for all fungi. It was found that the white rot *P. abietinus* was inhibited in its action to a greater extent than the brown rot *L. trabea* by the fungicide deposited from the wood-swelling vehicle. Since benzene and cellosolve differ in significant factors other than ability to swell wood, it remains for continuing work to show whether the same behavior is found with other white rots and other vehicles.

Literature Cited

1. ASTM. 1956. Report of Committee D7. ASTM 59th Annual Meeting.
2. Campbell, W. G. 1932. Biochem. Jour XXVI, 1829–1838.
3. Duncan, C. G. 1953. Forest Pathology Special Release No. 37. USDA Div. of Forest Pathology.
4. Duncan, C. G., and C. A. Richards 1950. Proc. AWPA 46:131–151.
5. Flerov, B. C., and C. A. Popov. 1933 Angewandte Botanik, 15:386–406.
6. Hatfield, I. 1944. Proc. AWPA 40: 17 67.
7. Leutritz, J., Jr. 1946. Bell System Tech Jour., 25: No. 1, 102–135.
8. Sedziak, H. P. Accelerated testing of wood preservatives. Mimeo. 0–149 Forest Products Laboratories of Canada Ottawa.
9. Stamm, A. J., and F. E. Harris. 1953 Chemical processing of wood. Chemical Pub. Co., 200–204.
10. Stamm, A. J., and R. M. Seborg. 1936 Ind. and Eng. Chem. 28: 1164–1169.
11. Wise, E., and E. C. Jahn. 1952. Wood Chem., 2nd Ed., Reinhold Pub. Corp 735.

Quality Control in the Sawmill[1]

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Every successful sawmilling operation practices some form of quality control, whether it realizes it or not. Analysis of the program at Brooks–Scanlon indicates both an increase in dollar value of end product and a lowered manufacturing cost. This paper covers the quality-control program from the log pond to the green chain.

THE TERM QUALITY CONTROL has acquired a great many interpretations, depending upon who is using it and where it is being used. Quality control is not something new to industry. It has only gained increased emphasis through terminology and necessity such as a buyer's market.

Quality control in the forest products industry is generally associated with plywood and furniture rather than sawmilling. However, it is felt that every successful sawmill operator practices some form of quality control, whether he realizes it or not.

Lumber has been loosely defined by the National Lumber Manufacturers Association as boards and other items that have been sawed from logs. The mere reduction of the log into component parts is not the manufacture of lumber, because standardization of the product is lacking. The sawmill operator must practice quality control to produce lumber, and the degree of quality control is responsible for the quality of the end product.

To cite an example, a request was recently made of a small sawmill operator to cut an order of dimension stock to certain specifications. Assurance was given that this could easily be done, but after the order was milled, no regard seemed to have been given to the original specifications. The operator was questioned about the inaccuracy of the cut, and stated that he had measured some of the boards from the head

[1] Presented at Session X, Lumber Manufacturing, FPRS 11th National Meeting, June 23–28, 1956, at Buffalo, N. Y.

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saw with a tape measure, and they had done the best that they could with the equipment available. By his actions, this operator was practicing quality control, though the means were extremely crude and not too effective. Therefore, we have come to learn that there are many degrees of quality control application.

In the manufacture of lumber and for the purpose of this paper, quality control means the procedures employed to produce the manufactured product to a set of standards, thereby obtaining the highest possible return from the log. Quality-control practices in sawmilling have as their goal the production of a controlled higher quality product and a reduction in manufacturing cost.

Brooks-Scanlon has initiated a program of studies and measures that will eventually extend from the log in the woods to the final product in the car. This paper covers the program as it has thus far been accomplished in the sawmill. It is not within the scope of this paper to enter into the mathematical background or the details of statistical quality control, although this is considered an extremely important function of any program.

The phases of sawmill operation at Brooks-Scanlon that are being studied from a quality control and manufacturing economy standpoint include the following:

1. The length accuracy of logs going to the headrigs.
2. A recovery analysis to determine the marginal-type log.
3. The accuracy of the cut as to thickness and width of lumber.
4. An analysis of the sawing procedures at the head-saw.
5. Maintenance of buildings and equipment.
6. Product improvement and utilization of residue material.
7. Lumber grading.

Log Lengths

A quality control problem was projected when a quantity of untrimmed lumber appeared at the planing mill. The cause for this condition was traced back to the log itself. It was found that as high as ten per cent of the logs going to the headrigs did not have the sufficient trim allowance, considered to be three to five inches per 16-foot log in the pine region. Logs were measured for full-day periods to determine the length accuracy of logs coming from the woods and the length accuracy of the bucking at the sawmill deck. Short logs were found to be coming from both places. The Logging Department immediately stressed the importance of accurate bucking in the woods, and now maintains control through periodic checks and continued emphasis. A combination electric eye-mechanical log stop was installed at the sawmill deck to increase bucking accuracy of logs at this point.

Logs going to the headrigs are now measured by quality-control personnel at periodic intervals to ensure that the trim allowance provided comes within the allowable limits. Increased significance has been given to the length of logs only after it was found to affect the quality of the end-product. Along with lumber complying more consistently with the high product standards of the company, it is estimated that over one million board feet of additional lumber is to be recovered annually by accurate bucking of logs.

The Marginal Log

The sawmill operator is interested in knowing what logs are marginal or submarginal to his operation, that is, which log pays its way through the sawmill. This point has become much more important to the operator in recent time, but as often as the query is presented, it is surprising how few actually have this information. Of course, this is an individual problem to every sawmill, and depends upon such conditions as operating expenses, log supply, market conditions, and utilization practices.

To check comparative log values, a recovery study was conducted by log specie and type. Separate studies were made on five classes of logs in question. Each class of log was followed from the woods through to the car. The actual sawing and related operation time for logs was recorded, and the lumber was marked. After the lumber was dried, the time required for planing was recorded and the lumber was graded and tallied.

It was determined from this survey that a minus conversion[2] return was being realized from much of the sawmill cut when converted to lumber. Approximately 14 per cent of the logs put through the sawmill are of this submarginal class, which could be better utilized in some other form of product.

Steps are now being taken to develop a product whereby the No. 3 and 4 common stock inventory will be greatly reduced, and a quality product with a positive conversion return will be realized. Sales department problems and inventory conditions will be alleviated through such action. There is no question as to the benefit for the manufacturer and consumer through an increase of quality by means of more intensive utilization.

[2] Minus conversion is used in reference to that product where the cost of raw material and manufacture exceeds the selling price.

Lumber Size Tolerance

It is normally agreed by the operator that, if quality control is to function in the sawmill, control of lumber thickness and width is most important and best lends itself to such a program. Frequent checking of lumber dimensions enables the operator to determine if the log volume is being sacrificed by cutting full or scant from the allowable limits. Lack of quality control here creates excessive waste and, therefore, correspondingly higher costs and a lower dollar realization.

In view of this, a program was established at Brooks-Scanlon whereby a continual check of lumber size tolerance is made. The standard quality control chart was supplemented with a per cent-defective chart. Ease of maintenance and understandability were the primary reasons for using this type of chart, at least for the beginning of the program. Fig. 1 shows an example of the lumber size tolerance record used.

The tolerance limits for thickness and width as used in coordination with the tolerance record are cited by Tables 1 and 2. The critical board positions to take measurements are considered to be within 18 inches from the end of the board and at the approximate headrig knee positions.

Table 1.—THICKNESS TOLERANCE LIMITS FOR GREEN LUMBER

	Green thickness	Tolerance limits
4/4	32/32	±1/32
5/4	1-15/32	±1/32
6/4	1-21/32	±1/32
7/4	1-15/16	±1/16
8/4	2-3/16	±1/16

Table 2.—WIDTH TOLERANCE LIMITS FOR GREEN LUMBER

Green width	Tolerance limits
4"	-1/4
6"	-1/4
8"	-1/4
10"	-1/2
12"	-1/2

In the early stages of the program, checks were made on 100 boards selected at random during each day from each of the three headrigs for thickness, width, and length. The percentage of lumber within the tolerance limits set for lumber thickness at this time was in the range of 80 per cent. Since that time, as compliance to a standard of 95 per cent and above has been reached, checks by quality-control personnel are made only once a week. This advancement in the control of quality represents a savings of approximately 500 to 750 dollars per day.

As an intervening check, key personnel carry thick-and-thin gauges for

GREEN LUMBER SIZES PONDEROSA PINE DATE:

THICKNESS				WIDTH RIG NO. 1										REMARKS
SIZE	% UNDER	% OK	% OVER	SIZE	UNDER	EVEN	1/8" OVER	1/4" OVER	3/8" OVER	1/2" OVER	5/8" OVER	3/4" OVER	7/8" OVER	
4/4				4"										
5/4				6"										
6/4				8"										
7/4				10"										
8/4				12"										
THICKNESS				WIDTH RIG NO. 2										
4/4				4"										
5/4				6"										
6/4				8"										
7/4				10"										
8/4				12"										
THICKNESS				WIDTH RIG NO. 3										
4/4				4"										
5/4				6"										
6/4				8"										
7/4				10"										
8/4				12"										

LENGTH AFTER SAWMILL TRIM				LENGTH AFTER DRY SORTER TRIM				LENGTH AFTER PLANER TRIM				REMARKS
SIZE	% UNDER	% OK	% OVER	SIZE	% UNDER	% OK	% OVER	SIZE	% UNDER	% OK	% OVER	
8'				8'				8'				
10'				10'				10'				
12'				12'				12'				
14'				14'				14'				
16'				16'				16'				
18'				18'				18'				
20'				20'				20'				

Fig. 1.—Lumber size tolerance record for thickness and width.

measuring thickness. Fig. 2 shows an illustration of the typical gauge used for this purpose. Such a gauge should be machined from 3/16-inch-thick stainless steel or brass to the tolerance limits established by the individual sawmilling operation. The width of the inside notch designates the minimum thickness for rough-green lumber, and the outside notch gauges the maximum thickness.

Western Pine Association Research Note No. 5.1123, March 1, 1956, revision, "Quality Control of Headrig Production", is recommended reading for sawmill operators further interested in the subject of controlled sawing accuracy.

Sawing Operation

An efficient head-sawing operation is one conducted in a manner that yields the greatest amount of high-quality production in accordance with the cutting practices employed, specie of logs, available equipment, and mill design. There is no doubt that the head-saw is the focal point for quality of the lumber product. Without quality recovery through good sawing practices, the problem of quality control throughout the remainder of the sawmill operation becomes increasingly more difficult.

Key control measures include the segregation of logs by headrig, taper sawing, knowledge of lumber grades at the head-end of the mill, and perpetual sawyer training. Logs are categorized into the three classes of 1) high-grade, large logs, 2) long, small, and rough logs, and 3) short, small, and rough logs, including chunks. Three headrigs are operated, each one normally sawing a particular type of log. In that way, the sawyer is able to confine his sawing interests, although he is certainly capable of breaking down all log sizes and grades. By means of such log segregation practice, quality and quantity production benefits.

Every sawbill posted informs the sawyer that taper sawing is to be continually practiced. Only in the small, short, and rough logs where taper sawing is not considered practical is an exception made. The posting of sawmill production sheets has long been discontinued. Quality of product is at stake when sawyers enter into productive competition.

Maximum turning of logs for grade is practiced, and it is not uncommon for larger logs to be turned as many as eight times. Only the very small, rough logs are sawed alive. Strict attention is given to such factors as log grades, turning practices, taper sawing, rate of feed, saw strain and lead, saw and pressure guide alignment, and saw filing. Quality of product and high recovery as prime objectives in the manufacture of lumber are considered to begin at the head-saw.

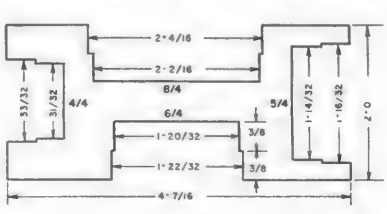

Fig. 2.—A typical thick-and-thin gauge for checking thickness of rough-green lumber.

The edgers are equipped with shadow-line guides that move with the saws. Presently being considered is a hydraulic saw shifting device to ease the work of the edgerman. This is expected to allow the edgerman more time to examine boards and cants, a benefit for quality edging.

Maintenance

Maintenance of buildings and equipment may be somewhat intangibly associated with quality control, but it is of utmost concern. The employee does his best work when the proper equipment is provided in good maintenance order, and when desirable working conditions surround him. No other manufacturing industry is quite so dependent upon the judgment of man as the sawmill. Under desirable working conditions, it is not uncommon for the employee to make suggestions that lead to economic savings and a higher quality product.

A modernization program has been initiated at Brooks-Scanlon which, it is felt, will increase employee morale, reduce maintenance costs, and ease quality problems. The maintenance shops and warehouse facilities have been concentrated under the back-end of the sawmill where neat, well-lighted and warm surroundings are provided. Modern equipment has been provided to ease working conditions for maintenance personnel. A few of the improvements of buildings and equipment that have been accomplished up to this date include the following:

1. Installation of a modern heating system throughout the sawmill.
2. Painting of the sawmill interior and machines in pastel greens and yellow to conform with industrial color codes.
3. Installation of slack absorbers to keep the carriage knees taut.
4. Installation of a carriage to process large logs more efficiently.
5. Installation of log flippers to work in coordination with the nigger when turning large, high-quality logs and cants.
6. Replacement of all plain and babbit bearings with ball and roller bearings.

Such improvements and others in the sawmill that have been made and are to be accomplished have as their objectives 1) maintenance of quality pro-

duction, 2) improvement of efficiency in operation, 3) promotion of safety, 4) reduction of manufacturing costs, and 5) closer log utilization.

Product Development

The forest products industry has recently been pushed into product improvement and development work because of higher cost of raw materials, increased operating costs, and integrated utilization standards. The industry has made great strides in this direction during a comparatively short time, with only a few frontiers being touched upon. This has been good for the industry.

It has been announced that Brooks-Scanlon, Incorporated, and Powell River Company, Limited, will combine forces in the future to construct a pulp and paper plant. As a result, a much higher degree of utilization will be possible, with increased concentrated practice on quality of product. There will be a selection of products to which the raw material may be converted. The higher grade logs will go into the manufacture of lumber, with lower grade stock being diverted to the pulp industry.

Lumber Grading

Quality control has been suggested as a means for controlling lumber grades. Some forest product industries other than the sawmilling industry are working in this direction, but to our knowledge, no milling operation has taken the step. Study of lumber grades by the quality control department would certainly be useful to the industry, and development along this line is certain to come about.

The lumber grading schools promoted by some organizations are doing an excellent job of emphasizing quality of production to the employee. It is one of the most direct means of making employees conscious of quality and bringing attention to practices that adversely affect it.

Brooks-Scanlon conducts a grading course under the direction of the Western Pine Association. Experience has been that such a course is highly accepted by all personnel. Admission is open to all plant personnel, with sawyers, edgermen, planermen, and office employees in attendance. Plant personnel, by becoming cognizant of grade and quality, are considered to benefit as much from the course as present and future graders.

Conclusions

Quality control in the sawmill is in a stage of such infancy that little information and experience is available. It is almost impossible to find for study good examples of extensive, successful, quality-control programs that are being conducted.

In a broad sense to some, ordinary lumber grading is quality control. But quality control and statistical quality control mean much more than just grading a product. The application of the techniques of quality control appears limited only to cost, time, effectiveness, and policy.

Often times, a particular operation may look good on the surface until quality-control measures are applied. Then it is revealed that significant amounts of time, material, manpower, and money are actually being used inefficiently with a direct effect on quality of product. This is effective evidence for the value of a quality-control program.

Not previously mentioned but to be considered as a benefit for any quality-control program is the psychological effect. There is the human element to contend with in any operation. It has been found that there is a considerable benefit from a psychological aspect to be derived from quality-control personnel conducting periodic checks of the operation. Much sawmill work is routine in nature. As long as the millmen know that management is interested in product quality by applying quality-control check measures, the workers become more interested in doing their best job.

The desirable relationship in any plant is one where production requests the services of the quality-control department. At Brooks-Scanlon, a step in this direction was taken when the logging department asked for specific studies to be conducted in the woods operation.

Quality control has been accepted in the broad sense for the purpose of this paper. Case histories have been presented that it is hoped will give an insight as to where a program could start and what may be accomplished. This may be a stimulus to others for further investigation and application so that the industry as a whole may benefit.

Bibliography

1. Bethel, James S. 1955. Quality control in the manufacture of wood products. For. Prod. J. V (1):45.
2. Bethel, J. S., A. C. Barefoot, and D. A. Stecher. 1951. Quality control in lumber manufacture. FPRS Proc. 5:26–31.
3. Bethel, James S., and Roy M. Carter. 1950. Techniques in hardwood plywood quality control. FPRS Proc. 4: 162–169.
4. Bicking, Charles A. 1957. Management possibilities with quality control methods. For. Prod. J. VII (1):16–19.
5. Brice, Dean C. 1956. Quality control of headrig production. Western Pine Association Research Note No. 5. 1123, revision.
6. Calahan, Richard C. 1953. How to make a quality control program pay off. Wood and Wood Prod. 58 (11): 21–22.
7. Calahan, Richard C. 1953. 10-point plan for setting up a quality control program. Wood and Wood Prod. 58 (10):25–26.
8. Carpenter, R. D. 1953. Quality control begins with logging. For. Prod. J. III (1):53–55.
9. Chapman, G. V., and E. Sigurd Johnson. 1950. Quality control in furniture production. FPRS Proc. 4:170–179.
10. Compton, Kenneth C. 1956. Increasing sawmill efficiency. For. Prod. J. VI (1):19–26.
11. Coats, Marvin W. 1956. A study of log lengths at the sawmill deck. A Brooks-Scanlon, Incorporated, Report.
12. Coats, Marvin W. 1956. An analysis of the head-sawing operation. A Brooks-Scanlon, Incorporated, Report.
13. Grant, Eugene L. 1952. Statistical quality control. McGraw-Hill Book Co., Inc. New York.
14. Grantham, J. B. 1950. Quality control in sawmill operations as practiced in class "A" Douglas-fir mills. FPRS Proc. 4:149–161.
15. Hader, Robert J. 1956. Some experimental designs applicable to problems with wood. For. Prod. J. VI (10): 425–427.
16. Juran, J. M. 1951. Quality control handbook. McGraw-Hill Book Co., Inc., New York.
17. Kreider, Charles M., and Marvin W. Coats. 1956. Special sawmill study to determine the marginal type log and pulp chip recovery. A Brooks-Scanlon, Incorporated, Report.
18. Latimer, Charles. 1953. Quality control of veneer and plywood manufacture. For. Prod. J. III (1):51–52.
19. Reed, L. O., and R. T. White. 1956. Statistical sampling proves efficient and accurate in receiving inspection. For. Prod. J. VI (12): 492–497.
20. Rutherford, John G. 1948. Quality control in industry. Pitman Publishing Corp. New York.
21. Rutherford, John G. 1954. Quality control cuts rejects and waste, raises efficiency. Wood and Wood Prod. 59 (8):32–34.

Discussion

W. L. Lear (Crossett Lumber Co.): How much thickness do you need to surface on?

Mr. Coats: 4/4 stock is cut a full 1 inch with a ± 1/32 inch tolerance limit permitted. This will satisfactorily yield a surfaced thickness of 25/32 inch without skips. Green lumber thickness takes into consideration the requirements for planing and shrinkage through the kilns. We are cutting 80 per cent ponderosa pine.

Mr. Lear: What were your tolerance limits, and what percentage were within the limits?

Mr. Coats: I would like to state that tolerance limits vary widely between mills, and that they should be established according to the particular operation. About 80–95 per cent of our stock falls within the tolerance limits prescribed by management as follows:

Thickness	Width
4/4 ±1/32 of 32/32	4″ + 1/8
5/4 ±1/32 of 1-15/32	6″ + 1/4
6/4 ±1/32 of 1-21/32	8″ + 3/8
7/4 ±1/16 of 1 15/16	10″ + 1/2
8/4 ±1/16 of 2-3/16	12″ + 1/2

Thickness gauges are also used. We have found that the go-no-go gauges are a very helpful aid.

Fred Simmons (Northeastern Forest Experiment Station): Some go-no-go gauges are used in the Northeast and are well liked.

A. C. Barefoot (N. C. State College): Go-no-go gauges are okay, but they have their limits, and good statistical quality control cannot be carried on safely with this gauge. Variables measurement provides more information and thus is more useful.

J. W. McNutt (William Milne & Sons): Have you ever considered an incentive scheme for rewarding men to increase quality in production?

Mr. Coats: Not to any extent. In quality control, it is a difficult thing to reward a select few since a program is so dependent upon the entire working unit. Interest is hard to generate, but it can be done with time. When a program is installed, you must start slowly and with diplomacy until it becomes instilled in the men's minds. Properly approached and with time, the employees will see the advantages of a program and realize their responsibility towards quality.

E. P. Ivory (Ivory Pine Co.): The term quality control has a rather definite meaning in the industry. How do you distinguish between quality control in a sawmill and such operations as grading, moisture determinations, or finished thickness?

Mr. Coats: Quality control and statistical quality control are two different things. Quality control as considered here means any increased measure of standardization or product quality beyond the extent of normal operating procedures. This excludes grading and moisture content determination as a part of quality control.

A Method of Quantitative Topographic Analysis of Wood Surfaces[1]

ROBERT A. HANN

Department of Wood Technology, University of Michigan, Ann Arbor

A method of numerically rating surfaces commonly found in the wood-using industries is described. Changes in surface topography are converted to strain, magnified by strain gages, and recorded continuously to form a profile, which is then evaluated statistically.

SURFACE DEFECTS CAUSE MUCH TROUBLE in the wood-using industries because the light reflected from any wood surface, such as a taple top, door, or floor, clearly reveals even very slight irregularities.

Irregularities that can be seen are of two types, those caused by operations performed on the surface, and those which result from a condition beneath the surface of a laminated product. The latter are called "telegraphing" defects. Examples of both types are shown in Fig. 1. Defects such as planer marks, that result from surface operations, can sometimes be discovered and corrected during manufacture, but telegraphing defects often do not appear until after the product is placed in service. Despite the importance of surfaces to the manufacturer of wood and wood-based products, efforts to minimize such defects have usually been unsuccessful. A principal reason is that there has been no precise way to evaluate the smoothness of a surface in a manner that would permit close comparison.

A method for evaluating different wood surfaces appears to be prerequisite to studies designed to minimize both types of surface defects. Telegraphing, as it relates to the core material, to moisture content, and to gluing procedure could be more accurately studied. Such a technique would provide a quality control test to indicate roughness of machined surfaces and to show conformance to prescribed standards. The literature shows little work in this field. Perhaps the greatest progress has been made by the metal machining and finishing industries. They have been aware of the importance of surface quality for many years, and have developed several methods of studying surface defects (5)[2]. This progress has not been matched in the wood-using industries.

Schwaner (6) studied some factors affecting telegraphing in wood, and found that a visual evaluation of sur-

[1] A 1957 Wood Award Entry.

[2] Numbers in parentheses refer to literature cited.

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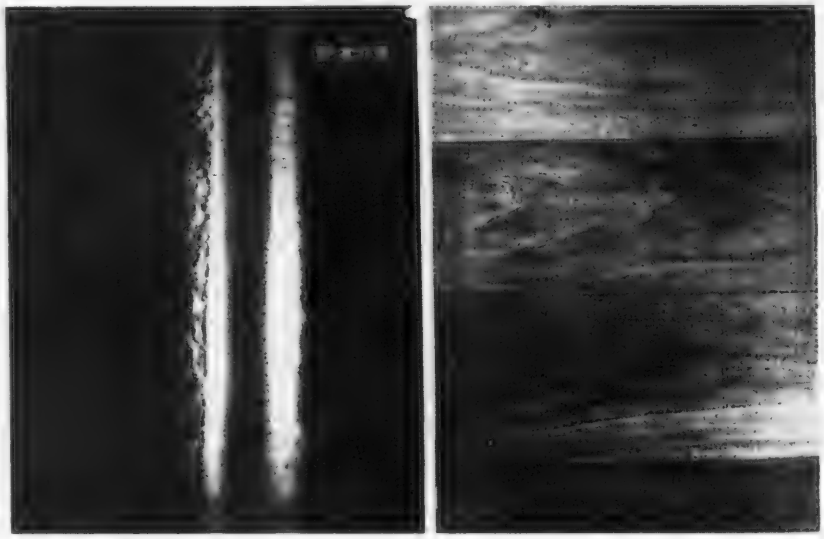

Fig. 1.—The two basic types of surface defects. The dimpled effect (left) can occur in veneered surfaces, while the planer knife marks (right) are caused by an operation on the surface.

faces was not accurate because luster, grain characteristics, and light source confused the appearance of the surface. He suggested that a magnified profile of the surface would be useful in such studies. Timber Engineering Company has adapted a Brush Surface Analyzer to record an extended profile of a wood surface, and the use of similar instruments in Europe has been reported. Means for interpreting the profiles obtained, however, have not yet made it feasible to describe a wood surface numerically.

The purpose of this paper is to describe a method of amplifying, recording, and numerically rating the profile of a wood surface. The method consists of 1) converting changes in surface topography to changes in strain by passing the surface beneath the end of a beam fitted with a probe, 2) recording the amount of strain continuously as a graph, and 3) evaluating the graph by measuring the deviation from an appropriate base line. The first section of the paper, the development phase, describes the apparatus that was developed, some tests that were used to check the apparatus, and the procedure of converting the profile to a numerical value. The second section, the evaluation phase, presents the results of three tests that were conducted to demonstrate that this method differentiates between different wood surfaces.

DEVELOPMENTAL PHASE

Apparatus

The apparatus consists of three basic components: the pickup arm, the amplifier-recorder, and the feed mechanism. The assembled apparatus is shown in Fig. 2.

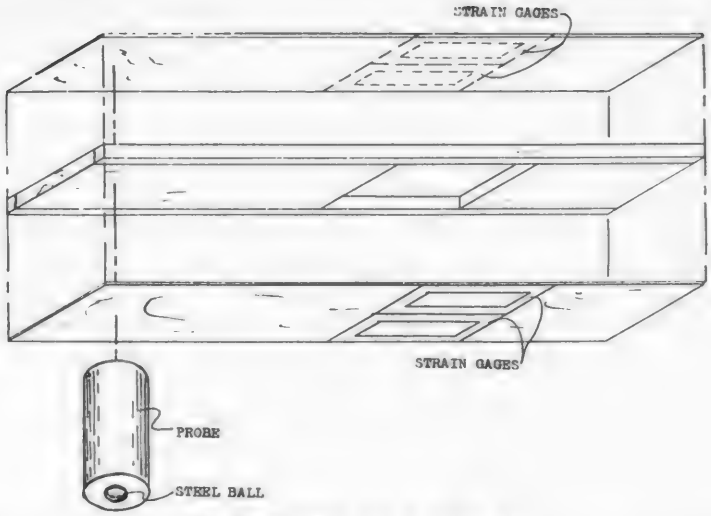

Fig. 3.—Exploded view of pickup arm.

The Pickup Arm. The purpose of the pickup arm is to sense and relay changes in surface topography presented by the specimen moving beneath it. Its parts are the strain gages, the probe that contacts the specimen, and the beam that serves as a mount for the strain gages and the probe. An exploded view of the pickup arm is shown in Fig. 3, and Fig. 4 is a photograph of the pickup arm contacting a specimen.

The beam is made of balsawood to reduce the stress required to give the desired strain. Damage to the surface of the specimen is thereby eliminated. The portion to which the strain gages are mounted is in the form of a box beam, while the remainder of the beam is solid. This concentrates the strain in the area of the strain gages, and develops maximum sensitivity.

Four SR–4 strain gages are mounted on the beam as shown in Figs. 3 and 4. They are connected so that vertical deflections are magnified, but horizontal and twisting deflections are self compensating.

The probe, mounted at one end of the beam, touches the surface being studied. It consists of a chrome steel ball partly imbedded in the end of an aluminum rod, which is bolted to the beam.

The diameter of the ball is an important consideration. It should be determined by the type of surface being studied and the information being sought. Studies of rough surfaces require a large ball, and anatomical studies require a small ball. The size used in this study, one-fourth inch in diameter, is considered satisfactory for studies of finished panels, machined surfaces, and particle boards.

The Amplifier-Recorder. A Sanborn Twin-Viso amplifier-recorder magnifies the strain in the pickup head and records it on a moving paper chart (Fig. 5). Both the speed of the chart and the amplification can be adjusted to give the desired amount of vertical and horizontal magnification.

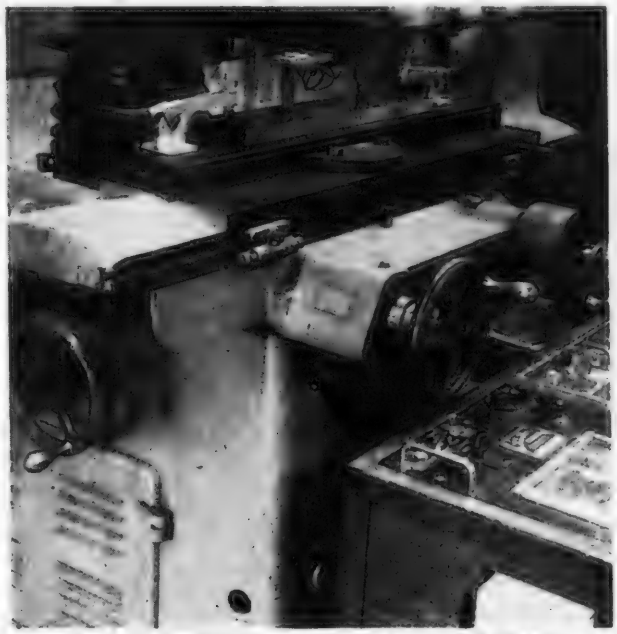

Fig. 2.—Apparatus used to obtain a magnified profile of various surfaces.

Fig. 4.—The pickup arm as it moves across the surface of a veneered particle board panel.

The Feed Mechanism. The feed mechanism provides a means of both holding the specimen firmly in a fixed position, and passing it at a constant rate beneath the point of the pickup head. The basic component of the feed mechanism is a Cincinnati close-tolerance grinder. The pickup arm is mounted on the grinder head. The grinder table, with its smooth ways and accurate adjustment, furnishes an excellent platform for the specimen (Fig. 2). An electric motor is connected to the drive wheel of the grinder table to drive the feed at a constant rate. To obtain the profile, the specimen is clamped to the table, adjustments for height and magnification are made, and the test run is completed.

Checking the Apparatus

The following tests were conducted to verify that the apparatus satisfactorily records the profile.

Reproducibility. The apparatus must trace identical graphs if the same part of a surface is passed beneath the pickup arm more than once. In short, it must give reproducible results. Also, in studies that require readings over the same path at different times, such as cyclic humidity studies, it should be possible to remove the specimen from the machine and replace it in the same position at any time.

To test the reproducibility of the apparatus and the method of locating the specimen, several specimens of different surfaces were tested twice, removed and replaced in the same position, and tested again. In all cases, the graphs for each specimen were essentially identical.

Calibration. Calibration is the best way to determine whether the instrument is giving constant amplification during testing and when starting a new test. It also is a convenient way of determining the magnitude of surface defects. The apparatus was calibrated in two ways: by observing the change caused by a one-thousandth-inch difference in gage-block height, and by raising the grinder table with its micrometer adjustment. Fine dust particles caused some error in the first method, while the latter method allowed some human error to enter. Both methods showed that a maximum magnification of 400 X could be obtained, however. This magnification permitted observation of irregularities as small as 0.0001 inch. Also, no change in magnification was found during testing.

Versatility. After the apparatus had been tested for reproducibility and calibrated, the profiles of surfaces that varied widely in roughness were obtained (Fig. 6). These profiles indicated that it is possible to record accurately the surfaces of plate glass, finished panels, and particle boards.

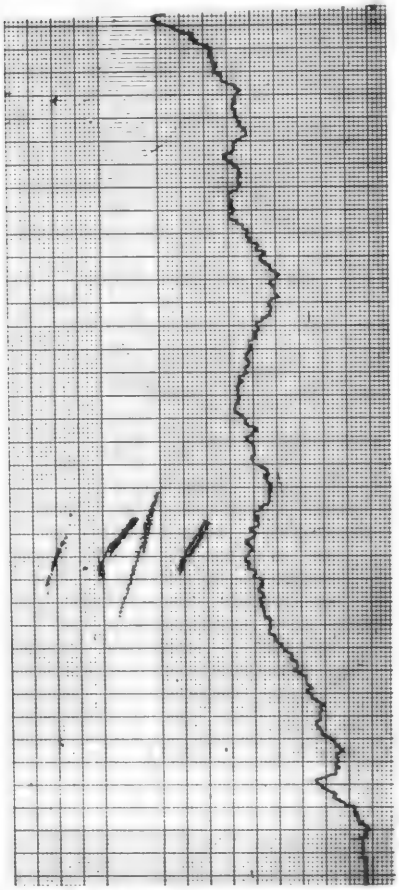

Fig. 5.—A full-scale reproduction of the profile of a veneered particle board surface, magnified 400 times.

Evaluating the Profile

Numerical evaluation of the graph is the most important step in analyzing the surface. It permits comparison of the surface with other surfaces at any time. A numerical value of a surface should describe that surface by numbers which will distinguish it from other surfaces that possess a different degree of roughness. Several possible ways to evaluate the profile were considered. One way was to determine the ratio of the length of the profile to the length of a straight line drawn through the profile. It is possible, however, for two different degrees of roughness to give the same value.

Another procedure, in which the area between the profile and a base line is measured by a planimeter, also may give the same values for surfaces that have a different degree of roughness.

A third procedure, in which the graphs of a surface before and after a humidity change are compared, gives important information for some studies but does not describe the surface itself.

The evaluation technique used in this study is adapted from a procedure used in determining the roughness of metal surfaces in which an average difference between the profile and mean line is determined (7). This difference is computed as the standard deviation of the profile from a horizontal line drawn through the graph. There are two distinct advantages to this procedure: it lends itself to statistical analysis, and it permits direct measurement of the deviations. In the case of wood, however, the procedure must be altered

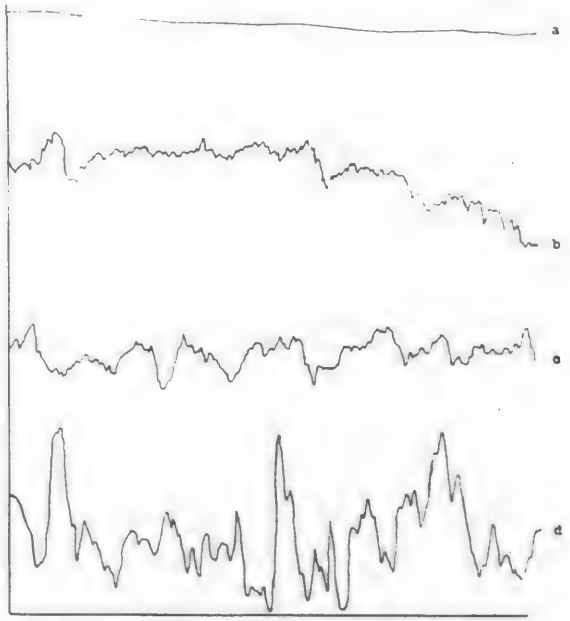

Fig. 6.—Profiles of four surfaces, recorded at 400 magnifications. a) plate glass, b) veneered particle board one day after veneering, c) veneered particle board after 4 weeks of exposure, and d) unveneered, sanded particle board.

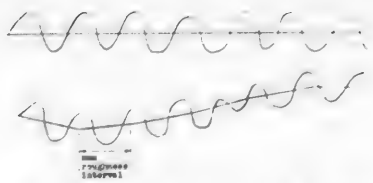

Fig. 7.—(Upper) Location of the mean line in a profile that shows only roughness. (Lower) Location of the mean line in a profile that contains gross deviations and roughness.

to allow for compensation of gross surface deviations such as warp. Gross deviations are those which cause the general shape of the profile to deviate from a horizontal line, and roughness deviations are local irregularities such as planer and saw marks, sunken glue joints, and telegraphing defects. When evaluating a wooden surface, it is desirable to eliminate the effect of the gross deviations, since they do not describe the surface itself. The effect of gross deviations was removed by using a mean line that conformed to the general shape of the profile. This meant that a flat surface, no matter how rough, would have a straight mean line, and a surface that contained a gross deviation such as a warp would have a curved mean line. The mean line was established by connecting short straight lines, called roughness intervals, that bisected the part of the graph through which they passed. The length of the roughness interval can be adjusted to accent either the roughness or the gross deviations. Roughness intervals thirty millimeters long were found to eliminate the effect of gross deviations the best without masking roughness.

After the mean line was located, the vertical departure of 25 per cent of the points on the graph selected at random was measured, and the following formula (1) was applied:

$$\text{Variance} = \frac{\text{sum } (X)^2 - \frac{(\text{sum } X)^2}{N}}{N - 1}$$

X = departure
N = number of departures

The resulting variance is used as the roughness value in describing the profile.

While the variance is not used by the metal industry, it was used in this study because it is quickly and easily determined and manipulated in statistical calculations.

EVALUATION PHASE

The Roughness of Planed Lumber

To determine that this method of surface analysis effectively differentiates between different amounts of roughness, surfaces of wood with varying amounts of roughness were compared. To vary the amount of roughness, matched specimens were planed at four different feed rates while the depth of cut was held constant.

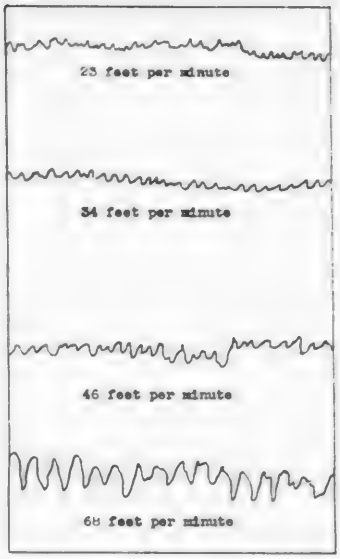

Fig. 8.—Profile of yellow poplar boards planed at four feed rates.

The surface of a planed board is composed of knife marks whose height and frequency are related to the feed rate, speed of the motor, number of knives, and depth of cut. According to Martellotti in "An Analysis of the Milling Process" (3), the height is related to the square of the feed rate. Therefore, since the roughness value is the square of the standard deviation of the profile from the mean, the square roots of the roughness values should be proportional to the feed rates squared. Portions of profiles obtained at different feed rates are shown in Fig. 8.

The roughness values are shown in Table 1, and a graph of the relation between standard deviation (square root of roughness) and feed rate is shown in Fig. 9.

These results indicate that the roughness value obtained by this method is an effective way of representing the roughness of a machined surface.

The Roughness Value of Veneered Particle Boards

One of the fields where it is felt this method of measurement may have practical application is furniture manufacture. The increasing use of particle boards as core materials for veneered and highly finished panels has given rise to new problems. Of particular interest is the problem of telegraphing which involves show-through of edge banding, and surface and subsurface particles. Since this is a problem of topography change, a means of quantifying defects should be helpful in leading to a solution.

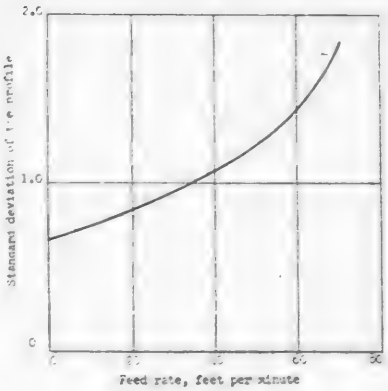

Fig. 9.—Relation of feed rate to the roughness of planed lumber.

Table 1.—THE ROUGHNESS OF LUMBER PLANED AT DIFFERENT FEED RATES

Feed rate, feet per minute	Roughness value
23	0.69
23	.68
23	.74
34	.97
34	.94
34	.99
46	1.18
46	1.24
46	1.41
68	3.68
68	3.42
68	3.10

To illustrate the applicability of this method of surface analysis in the general area of particle boards, a number of profiles made on two different types of board under various treatments were evaluated. Treatments included veneering with two different glues, and a moisture-content change.

Specimens of vertically extruded and three-layer, platen-pressed particle board were veneered with 1/32-inch yellow birch veneer and a hot-press formulation of ureaformaldehyde and a contact cement.

The urea panels were pressed at 50 psi, and the contact-cement panels were pressed at 10 psi. Extruded panels were veneered with the face grain parallel to the direction of extrusion. Both the veneer and the particle board were initially conditioned at 4 per cent emc conditions until equilibrium was reached.

The profiles of the extruded specimens were made parallel to the direction of extrusion. A 6-inch profile of each panel was obtained one day after veneering, and again after four weeks of exposure at 16 per cent emc conditions. Both profiles were obtained over the same path. The profiles of unveneered particle boards were also evaluated for controls. The results are shown in Table 2.

The data show marked differences in roughness values as a result of treatment. These differences are: 1) Be-

Table 2.—ROUGHNESS VALUE OF TWO TYPES OF PARTICLE BOARD VENEERED WITH TWO TYPES OF ADHESIVE AND SUBJECTED TO 12 PER CENT MOISTURE CONTENT CHANGE FOR FOUR WEEKS

Board type	Replication	Roughness value								
		Unveneered			Veneered					
					Urea adhesive			Contact cement adhesive		
		Initial	Final	Change	Initial	Final	Change	Initial	Final	Change
Extruded	1	15.26	36.85	21.59	0.54	4.16	3.62	2.77	7.28	4.51
	2	10.85	65.25	54.40	2.76	4.55	1.89	4.33	11.31	6.98
	3	10.25	26.89	16.64	2.65	4.38	1.73	4.75	7.80	3.05
	Av.	12.12	42.99	30.88	1.98	4.36	2.41	3.95	8.79	4.85
Three-layer platen	1	5.11	5.00	.11	1.27	4.38	3.11	2.46	2.05	0.41
	2	2.37	21.62	19.25	3.74	5.07	1.33	3.85	5.79	1.94
	3	2.80	2.85	.05	2.12	2.65	0.53	4.30	3.81	0.49
	Av.	3.43	9.82	6.80	2.38	4.33	1.66	3.54	3.88	.95

Table 3.—THE EFFECT OF VENEERING PRESSURE ON THE ROUGHNESS OF VENEERED EXTRUDED PARTICLE BOARD

Veneering pressure	Replication	Smoothness value		
		Initial	Final	Change
50	1	0.54	4.16	3.62
	2	2.76	4.55	1.79
	3	2.65	4.38	1.73
	Av.	1.98	4.36	2.41
100	1	1.69	2.15	.46
	2	2.85	4.89	2.04
	3	3.33	7.59	4.26
	Av.	2.62	4.88	2.25
150	1	5.64	4.93	.71
	2	2.53	2.14	.39
	3	3.49	5.16	2.12
	Av.	3.88	4.08	1.07
200	1	5.30	10.07	4.77
	2	2.58	6.33	3.75
	3	3.76	9.12	5.36
	Av.	3.88	8.51	4.63

tween unveneered boards, both initially and after a moisture content change. 2) Between veneered and unveneered specimens of the same board after a moisture change; also initially for the extruded board. 3) Between replications of the same board, after a moisture change. 4) Between adhesives used on the extruded board after a moisture content change.

No significant differences existed: 1) In the initial roughness of either board veneered with either adhesive. 2) In the roughness of either board after moisture content change, when veneered with urea adhesive. 3) Initially between veneered and unveneered three-layer, platen board.

The results show that this surface-analysis technique accurately differentiates between surfaces that have varying amounts of telegraphing irregularities, thereby indicating that it is applicable to studies of factors that affect telegraphing.

Change in Roughness Value as an Indication of Optimum Veneering Pressure

A factor often associated with telegraphing of veneered particle boards is the bonding pressure used to apply the veneer. This factor causes local differential compression stresses as a result of density differences and particle orientation. Subsequent release of these stresses results in changes in surface topography. Moisture content changes further compound the ultimate effect of such stresses. The following experiment shows the utility of the roughness value in tracing the course of these effects.

Twelve 6-inch by 6-inch specimens of an extruded particle board were veneered with sheets of 1/32-inch yellow birch at four different pressures; three each at 50, 100, 150, and 200 pounds per square inch. The adhesive was a hot-press urea formulation. The grain direction was always parallel to the direction of extrusion.

The specimens were allowed to reach equilibrium at 4 per cent emc conditions, and were then sanded in a drum sander, veneered, returned to the 4 per cent conditions for one day, and tested. All specimens were tested parallel to the grain direction of the face veneer.

The specimens were then placed in 16 per cent conditions for one month, and were retested over the identical traverse followed initially. The results are shown in Table 3.

There are two different trends apparent in these results. The initial smoothness is at an optimum at the lowest pressure, but the least change occurs at 150 psi.

The tests are not extensive enough to permit explanation of these trends, but the fact that they appear in the results further indicates that this method could be successfully used in expanded studies.

General Discussion

This method of surface analysis is quite versatile. The size of the specimen can be varied without difficulty, and the magnification can be adjusted by stages from 1 x to 400 x.

Potential applications of this technique are numerous, and one of the most promising is in quality control for particle board manufacture. The uniformity of the board could be effectively checked by determining the roughness of different samples after a short, severe exposure. By cutting small samples, both the manufacturer and the consumer could predict the performance of the board once the properties have been determined.

The studies of various surfaces performed to determine the usefulness of the method have provided some fundamental data that can later be used in a study of telegraphing in particle boards. Telegraphing as defined in this paper exists in most laminated surfaces, yet all these surfaces are not considered defective. The relation between measurable roughness and observable telegraphing is not well defined. As mentioned earlier, observation of telegraphing depends on many factors that cannot be directly measured. This technique provides a means of studying the factors that affect the tendency to telegraph. Such studies could show how telegraphing can be minimized, perhaps to the extent that it would no longer be a defect.

Literature Cited

1. Duncan, A. J. 1952. Quality control and industrial statistics. Richard D. Irwin, Inc.
2. Ernst, G. G. 1945. The use of SR–4 strain gages in the testing of wood and wood-base Materials. U. S. Forest Prod. Lab.
3. Martellotti, M. E. 1940. An analysis of the milling process. Proceedings, ASME.
4. Perry, C. C., and H. R. Lissner. 1955. The strain gage primer. McGraw–Hill.
5. Reason, R. E. 1944. Surface finish and its measurement. Jour. of the Inst. of Prod. Eng., Oct.
6. Schwaner, R. M. 1957. A survey of the factors affecting telegraphing. Unpublished master's thesis, U. of Mich.
7. U. S. Superintendent of Documents. 1955. Surface roughness, waviness, and lay. MIL–STD–10A, 13 Oct.

Wood Fillers to Improve Furniture Finishes[1]

PAUL A. BLACHMAN

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The primary purpose of the paper is to enlighten personnel who select and use wood fillers in regard to composition, testing, evaluation, causes relating to filler failures, the economics involved in using wood fillers, and the outlook on future technical advances. A secondary purpose is to promote a mutual understanding of problems between paint manufacturers and furniture manufacturers.

WOOD FILLERS HAVE BEEN IN USE for several centuries. Oddly enough, despite many and rapid technological advances in film-forming coatings, the general concept of wood filler composition has remained stagnated throughout this period.

Until very recently, the average wood filler consisted of a bolted mixture of raw or boiled linseed oil, or both, fossil or natural gum japans, silicious inerts such as Silex, various natural earth colors, and small percentages of water. These fillers, when properly used, were characterized by slow thru dry, moderate filling and shrinkage, and good film supporting qualities. Finishers of this era advocated the practice of double filling such wood forms as oak, chestnut, mahogany and walnut, coupled with curing cycles of 24 hours or longer. Double filling was considered a necessary technique predicated on the fact that the single inert phase allowed a considerable percentage of air space in the filler pore, which gave rise to pinholing, excessive shrinkage, or both. This type of filler composition, with only minor or moderate modifications, held its place in our industry up to the introduction of the conveyor production technique. It was at this point in the progress of furniture finishing that a greater effort was expended in the formulation and composition of wood fillers.

Filler Composition

If the full intent of this paper is to be met, it is necessary that filler composition be thoroughly understood. Table 1 shows a comparison of two typical wood fillers (Medium Walnut Color) currently being used by furniture manufacturers.

Table 1.—COMPARISON OF WALNUT WOOD FILLERS

Composition	*Med. Vehicle Content*	*Low Vehicle Content*
Abestine) Silica) Terra alba) Suspending aid)	61 pounds	63 pounds
Total vehicle solids	18.68 pounds	12.50 pounds
Thinner and solvents	4.50 pounds	8.68 pounds
Colored pigments	14.82 pounds	14.82 pounds
Alkaline water	1.00 pound	1.00 pound
Total	100.00 pounds	100.00 pounds

It is readily apparent here that the prime difference between these two commercially acceptable fillers lies in the ratio of vehicle to thinner to dry pigment. There is a very important significance in this ratio in relation to the adhesion properties as well as the life expectancy of the completed finish. For instance, the oil absorption or, more specifically, the weight of oil required to wet out the inert and pigment portion of the filler is 18.33 pounds. Obviously, the medium vehicle filler has just covered this basic requirement, while the low vehicle filler falls about 30 per cent short of the requirements. Since the great bulk of the filler composition is white in its native state (inerts), the filler tends toward "graying" in the pore. The addition of vehicle solids to the filler will bring the inerts into a "Colorless transparency" and away from graying.

Fig. 1 demonstrates a comparison of two identical fillers at two levels of vehicle solids. At the time of application, these colors were identical. The gray washed out appearance of the low vehicle type occurred several hours after the final lacquer coat was applied.

Fillers that are compounded in the range of 12.5 per cent of vehicle can be expected to give rise to another type of failure. The inert phase of the filler develops a rather high hydrostatic pressure. Simply interpreted, this means that the thirsty inerts will tend to leach the oils and chemical plasticizers from the sealer and top coat lacquer to satisfy this thirst the result is weakening of the film structure, and finally gives rise to premature grain checking. Commercial fillers are formulated and used at this low vehicle level for two reasons: cost, and ease of working. It is well established that the lower the vehicle content of the filler the easier it will pad (said to be pigment lubricated).

The modern wood filler offers the finisher a better pore pack compared to the Silex filler by virtue of its improved inert system. Today's formulators do not restrict themselves to Silex

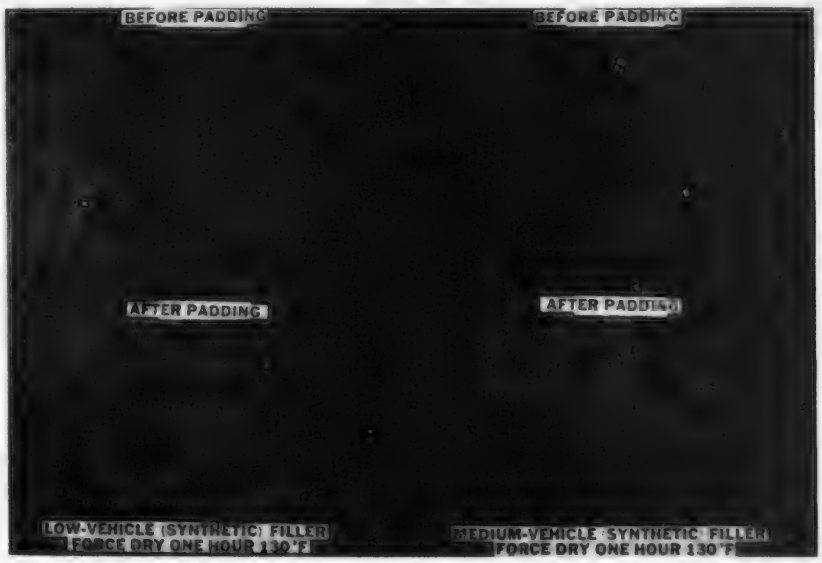

Fig. 1.—Comparison of two identical fillers at two levels of vehicle solids.

[1] Presented at Session IV, Wood Finishing, of the 11th National Meeting of the FPRS, June 23–28, Buffalo, N. Y.

The Author: Paul Blachman joined the Glidden Co. in 1934, and advanced to assistant research chemist in inorganic pigments, lakes, and dyestuffs. He has spent the past 12 years in formulation, product development, and color styling. He studied in chemistry of engineering and materials with the Penn. State Extension School.

or silica alone, but rather use a multiplicity of inert pigments, each of which serves a definite useful function in the system. Generally speaking, wood fillers contain asbestine, which is a long, pointed, needle-like structure (acicular). Asbestine serves the function of improving suspension of the reduced filler in the pore by spiking itself into the cell wall and extending outward and over the other filling ingredients. The silica in its many forms provides the bulk with which to pack the pore, and improves hardness and adhesion to the system. Terra alba is a soft, impalpable powder that is mobile enough to fill in the voids left by the irregular, spherical silica crystals, and thus contributes to tighter pack with lessened air space. It thereby reduces the tendency to shrink and pinhole. The vehicle contained in the filler provides, in addition to its binding power, air displacement in the wood structure and lends a preservative action to the wood form. The proper choice of vehicle provides clarity and richness to the finish, and at the same time provides an improved bond between the wood and the finish coats. An alkaline water solution is usually added to the filler to form a water-inside-phase emulsion, which greatly improves suspension and ease of wiping. Overly emulsified fillers will not fill pores satisfactorily because the emulsion fails to "break" and the system is "cushioned" under the pad. When this condition occurs, the filler carries "bound" solvent into the pore, which prevents packing and results in hungry grain.

Wood fillers are by no means limited to the composition described above. Undoubtedly, all manufacturers and formulators have developed systems based on type of binder, suspending agent, and so forth, which encompass wide latitude in the selection of ingredients. It is only the intent within this paper to provide the finisher with a broader scope relative to the products he uses in his daily work.

Test and Evaluation

There is no standard test procedure established for wood fillers predicated on the wide scope of end usage. Primarily, the filler in question should be tested within a minimum and maximum time and temperature cycle in which it will be used. It is suggested that panels 12 by 24 inches or larger be used for the evaluation, and that they be prepared exactly as they will be used in production. A recommended procedure in the evaluation of the filler is to leave a portion of the test panel unwiped. At the end of the dry cycle the filler can be checked for dry and binding ability by simply pushing with the thumb. A composition can be judged as unsatisfactory in end use if the filler is wet or tacky (pinholing and blushing will result under adverse atmospheric conditions), or if the film tends to powder or crumble (graying and grain checking will result).

If the composition seems satisfactory under this test, recoat the system with the sealer or lacquer that is intended for use in the finish. Note the color before recoating, after recoating, and again 24 hours later. The color will become deeper, fuller and richer after the panel is recoated.

Note at this point whether there is any unusual gassing or surface activity. Gassing will indicate incomplete cure or a filler that contains a hydroscopic agent, which will give rise to pinholing. If the film tends to rope or swell, the filler is not curing properly or the system is completely incompatible. After 24 hours' cure, the color should retain nearly the fullness or depth it had attained when the panel was first recoated. Loss of color value indicates a filler with too low vehicle solids content. Such a composition will tend toward graying and loss of adhesion in end use.

Naturally, the filler should be evaluated for ease of wiping, clean-up, clarity, and the ability to pack the pore. Too often, finishers will select a filler because of its easy wiping qualities to the exclusion of all else. An easy wiping filler usually denotes low vehicle solids, with the attendant deficiencies noted above. Further, a low vehicle filler system is naturally pigment lubricated, and usually imparts a gray haze to the finish. Higher vehicle contents produce clearer colors with better film integrity, despite the fact that they require more physical effort in padding. It is also a good practice in

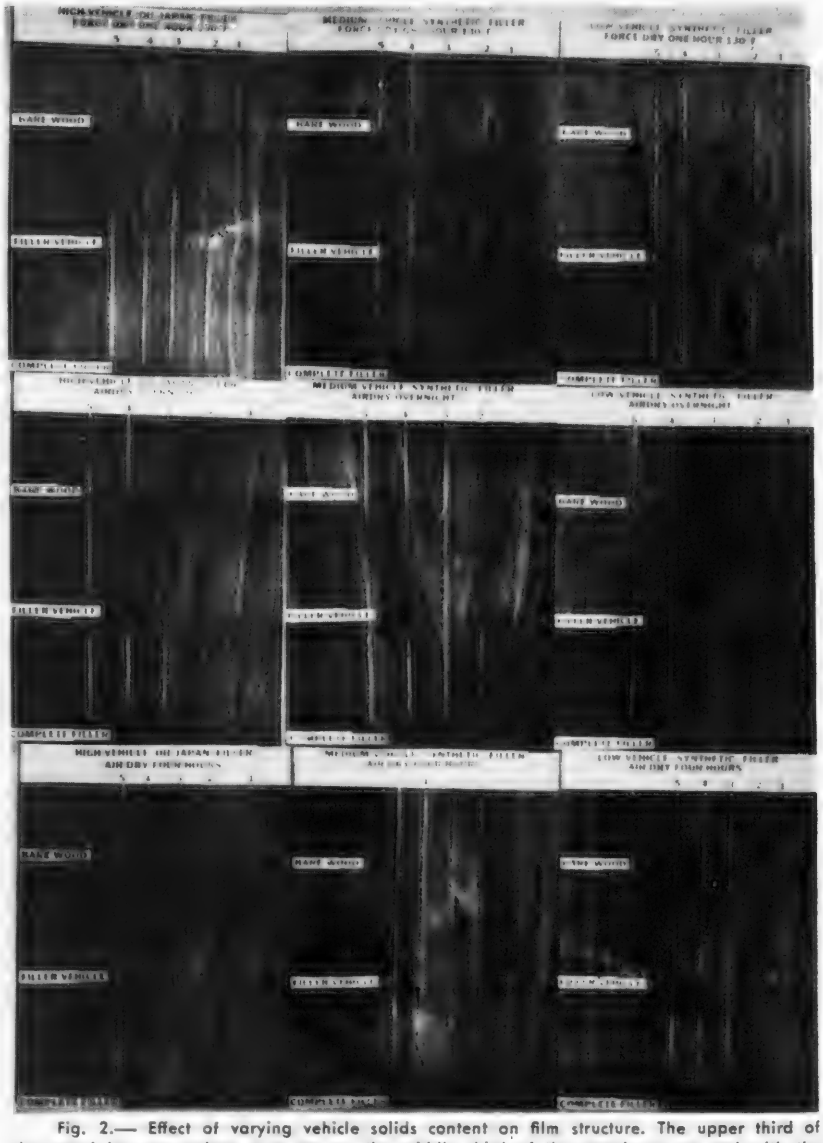

Fig. 2.— Effect of varying vehicle solids content on film structure. The upper third of the panel has no undercoat treatment, the middle third of the panel was treated with the filler vehicle only, and the lower third of the panel was filled with the complete filler under test.

preparing the test panel to leave a portion of the panel unfilled but finished completely with the remainder of the finishing materials. The finisher is then in a position to judge the effect the filler exercises on the finish, and conversely whether the sealers and lacquers are adequate for the job.

Filler Effects on Film Structure

The contention that fillers made at varying vehicle solids content markedly influence the film structure is shown in Fig. 2. Five-ply walnut face veneer panels (9 by 12 inches) were divided into three equal sections and then finished in the following manner: The upper third of the panel has no undercoat treatment; the middle third of the panel was treated with the filler vehicle only; the lower third of the panel was filled with the complete filler under test. All panels were coated with two coats of a conventional amber lacquer of average commercial quality (no sanding sealer in the system) and all panels were then aged three months at room temperature and humidity. At the end of the period, the panels were tested for adhesion and film strength with the Gardner Adhesion Tester (Fig. 3.) This instrument consists of a rounded stylus supported on a variable-tension, spring-loaded shaft. Panels were evaluated for film characteristics at spring settings of 1, 2, 3, 4, and 5. A moderately good quality furniture finishing system will normally show signs of "bridging" with this instrument set at number 3 on the scale.

Two different vehicle systems were evaluated in this study: synthetic and oil-japan. The synthetic systems were further sub-divided into medium and low vehicle solids type, and the oil-japan system was maintained at or near the highest vehicle solids level commensurate with good padding properties. The test was further broadened to include each of the systems named under three common end uses: Force dried 1 hour at 130° F.; air dried 4 hours; air dried overnight.

Conclusions from Panel Tests

1. When air normally present in the wood structure is displaced with a drying liquid, the wood structure assumes a greater density, which, in turn, promotes better adhesion between the wood surface and the lacquer finish coat. This is contrary to the popular belief that oils and synthetics under lacquer tend to destroy film integrity. This conclusion is reached by noting the degree of film failure (at the same instrument setting) between the untreated and vehicle-treated segments of the panels. This difference in film integrity becomes more apparent when the instrument is set in its No. 3 position.

2. These same oils, when distributed over a high specific area such as occurs when filler inerts and colors are added, produce a condition whereby air in the wood structure is not displaced with a densifying liquid. Hence, adhesion of lacquer finish suffers immeasurably. This phenomenon is further complicated when the ratio of vehicle to pigment is of such a low order as to disrupt film continuity. The result is a foundation for the subsequent lacquer coats that has no inherent strength within itself. Again, the results are poor adhesion and poor film structure. This conclusion is reached by noting that the synthetic filler, with either low or medium vehicle solids, fails at instrument settings of a lower order than the failure points of the vehicle-treated segments of the panels. Further, it should be of prime interest that the failure point of the low vehicle solids filler is setting No. 2 in all dry schedules, while the failure point of the medium vehicle solids filler occurs at setting No. 3. This difference is conclusive proof that a wood filler is dependent on vehicle solids for film strength.

3. The higher vehicle solids oil-japan filler series point out that the filler must be specifically designed for the end-use drying cycle. It may be seen that this filler contributed to break down of the film at the No. 2 setting when forced dried for 1 hour at 130° F., but the film did not fail until a No. 4 setting was reached on the other two schedules. The conclusions reached from this test again indicate that vehicle solids are of prime importance if film structure is to be improved, and that raw oils are not best suited for fast heat schedules.

Economics

The conclusions reached from the tests reviewed all indicated that wood fillers at low levels of binder deteriorate the finish, while those at higher levels tend to improve the service life of the finish. The question naturally arises as to why low-binder fillers are offered and used in the furniture industry. One contributing factor is that labor consistently resists the greater effort required in padding and cleaning the higher vehicle type fillers. The workers have not been educated to the extent that they concern themselves with quality of product, and consequently, they harass management constantly when their daily chore is more difficult. As a result, management insists that the filler manufacturer provide the necessary relief, and the quality of end-product suffers.

Even more important is the attitude of management toward the price of wood fillers. It is commonplace to hear

Fig. 3.—The Gardner Adhesion Tester for determining adhesion and film strength.

the purchaser say that he "never paid over 15 cents a pound for filler in his life", and it is just as commonplace for the filler manufacturers to regard filler as a "give away" item so that more business might be attained. To back his philosophy, he removes from the filler formula as much of the expensive vehicle as he dares, and again the quality of the end product suffers. A review of the economics from both viewpoints should serve the function of creating interest in better quality of finish, more satisfied customers, and better profits for all concerned. Table 2 shows the actual cost breakdown of the medium oil length filler used in the test described in this paper.

Table 2.—COST BREAKDOWN—WALNUT WOOD FILLER (Medium Oil Length)

Raw material	$8.43 per cwt.
Manufactured cost	3.60 per cwt.
Package	2.80 per cwt.
Freight per 100 miles	1.25 per cwt.
Delivered cost	$16.08 per cwt.

Fig. 4.—The above panel was aged for three months, then tested with the Gardner instrument. The top segment failed completely, and the bottom segment withstood aging the best.

Obviously, it is impossible to sell this product to the 15-cent-per-pound market, and the only answer to this market is the low-binder type filler. It stands to reason that the paint industry can not be called upon to subsidize any part of the products it sells and still maintain a reasonably sound financial structure. Hence, it formulates to a "price." Table 3 provides a basis of comparison of direct interest to the furniture manufacturer.

Table 3.—FILLER MATERIAL COST COMPARISONS.

Filler sprayed at 8-pound cut.
Average coverage (including losses) equals 128 sq. ft. per gallon.
Reduced gallon ready to spray) 4.8 pounds of filler
.6 gallon of naptha

Naptha @ 30¢ per gallon
Filler @ 15¢ per pound
} 90¢ per reduced gallon

Naptha @ 30¢ per gallon
Filler @ 24¢ per pound
} $1.38 per reduced gallon

60-inch Triple Dresser contains 27 sq. ft. area
@ 128 sq. ft./gallon, 0.211 gallon reduced filler used per unit
@ 15¢ per lb. for filler, material cost per unit is 19¢
@ 25¢ per lb. for filler, material cost per unit is 29¢
Additional cost per unit is 10¢

It can readily be seen that the cost of filler versus the total cost of the unit is exceedingly small. It is also obvious that boosting the price of the filler by 60 per cent adds only a small increase to the cost of the unit. From the paint industry's point of view, this increase in selling price points toward profitable returns, and thus stimulates interest in product improvement to capture a segment of the available market. Certainly when an item is profitable, American industry has always demonstrated its interest in improvement by research and development. It is conceivable that, once started, the competitive spirit of the paint industry would invest research dollars toward solving the problem of creating the as yet unknown binder-filler system that will serve to improve working properties as well as life expectancy of the finish. It seems to follow logically, especially in view of the current buyers' market, that such a low cost increase factor balanced against the possible end result represents the best bargain that could possibly be offered the furniture industry.

Wash Coat

Any attempt to evaluate fillers alone with no thought to the wash coat used in the system would be misleading. In the average system, the wash coat is the first binder-containing material applied to the wood surface. It follows that the characteristics of the initial coating will bear greatly on the adhesion and integrity of subsequent coats. The finisher who regards the wash coat as a necessary nuisance operation dedicated only to the task of keeping the finish clear is indeed laboring under a misapprehension. Actually, the wash coat anchors the entire finishing system to the wood substrate. By way of illustration, a walnut panel was divided into three segments (Fig. 4). The top segment was wash coated with reduced lacquer sealer, the middle segment was wash coated with reduced lacquer, and the bottom segment was wash coated with a specially prepared synthetic. A medium-length filler was then applied, followed by two coats of commercial grade amber lacquer. The panel was aged for three months, and was then tested with the Gardner instrument. The segment that was wash coated with reduced sealer failed completely. The reduced-lacquer segment showed bridging on a No. 2 setting, while the segment that was wash coated with the synthetic rated between settings of 3 and 4.

The practice of reducing sealer for wash coat is fast losing ground in the face of the industry trend toward improved quality. Sanding sealers normally contain 5 to 7 per cent of their solids composition as a metallic stearate, whose function is to provide a lubricating action under sandpaper. It has been demonstrated that when such composition is reduced and applied to the wood form, a separation takes place wherein the resins and plasticizers tend to migrate into the wood cells and leave a microscopic film of the metallic soap on the surface of the wood. This soap film, coupled with the normally short, brittle nature of the average sealer, tends to rob the system of adhesion and length. The use of reduced lacquer for wash coating is a considerable improvement over sealer, as shown in Fig. 4. Quality lacquers, however, are formulated for length to insure long life expectancy. Formulations of this type tend toward cohesion at the expense of adhesion; hence, they do not provide the ultimate anchorage for a finishing system when used for wash coating. The use of specially prepared wash coats, despite the higher costs, is rapidly gaining favor because the formulating chemist can use resin-plasticizer systems that do not tend toward cohesive forces when the desired length is attained.

Application

Perhaps the most controversial facet involving wood filler is the method of application. The finisher of yester-year, whose schedules were lengthy, adapted himself to brush application of filler cut to 12 pounds per gallon. He theorized that, by working a heavy filler cut with a brush, he was forcing the filler into the wood pore. To some extent this theory held true in practice, but at the same time that filler solids were being worked into the pore, the carrier solvent also found its way into fibrous miscelles at the bottom and ends of the wood pores. This solvent is subsequently trapped in the padding operation, and contributes to shrinkage and hungry grain.

Spray application of wood fillers has steadily gained in popularity as more finishing rooms are conveyorized. It is common practice in spray application to cut the fillers to 6 or 7 pounds per gallon and flow on a thin coat. The flow coat is then flashed for 1 to 3 minutes, after which it is pre-padded with a rotary wheel. The filler is then padded and cleaned in the conventional manner. The criticism here again is directed toward the slush spray technique, wherein the padding wheel carries too great a volume of solvent into the pore. This solvent is not expelled until the filler is in the drying process As in the case of brushing, shrinkage is the end result.

Spray application of filler cut to 10 pounds per gallon has been worked successfully both in the laboratory and on production lines. The significant difference over conventional practice is to atomize the filler solution with 40 to 45 pounds air pressure by means of a moderately wide fan. The filler solution should strike the work in such condition that it will not run or sag. The higher atomization serves the double function of "breaking" the emulsion and at the same time getting the carrier solvent into the atmosphere rather than on the wood. The filler in a semi-dry state should form a continuous film with all wood pores clearly outlined. After 1 or 2 minutes of flash-off, the filler should be pre-padded with a rotary wheel pad, followed by conventional padding and cleaning. This technique will insure a greater amount of filler solids in the pore, with less shrinkage. The primary drawbacks to this technique are that more filler is consumed per unit than in any other method, and again the wiping operation requires more physical effort. The end seems to justify the means in this instance, and it should be well worth the finisher's time to experiment with the technique.

Summary

It must be recognized and conceded by both the paint and the furniture industries that the ideal filler compositions are still in the future. To keep that future from being relegated to the "far distant", certain concessions will have to be made in both industries.

The prime obstacle to overcome is price structure; wood fillers must be advanced to a point where they become profitable sales items. The paint industry must then accept the challenge of creating through chemical study a vehicle-pigment system that will work well mechanically and, at the same time, contribute constructively to the integrity of the finishing system. Of nearly equal importance is a re-education of personnel who handle fillers on the production line. These people must be made to recognize their responsibility in the over-all up-grading of the final product, and should be willing to work harder to attain that objective. The recent up-swing toward improved quality of finish, first in the midwest and more recently in the southeast, clearly indicates the trend of a buyer's market. This trend will have to be met if the furniture manufacturer is to survive against competition. Obviously, the answer to survival is progress, and the two steps mentioned should lay the foundation for all future progress in the furniture finishing field.

Discussion

R. M. Carter (North Carolina State College): Does the Gardner test for adhesion evaluate, as you used it, the film adhesion alone or does it include other film properties?

Mr. Blachman: Only that of adhesion.

Frank Parrish (Heywood-Wakefield Co.): Was filler adhesion to lacquer the main test?

Mr. Blachman: Yes. For vehicle ratio tests, sealers were not used so as to influence adhesion. Adhesion was the first step. When this is resolved, further tests will be made.

The "What, Why, and What From" of the FAO/ECE International Consultation on Insulation Board, Hardboard, and Particle Board[1]

WAYNE C. LEWIS

Engineer, Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

The planning, purpose and operation of the meeting are discussed. The types of information available in secretariat writings, proceedings, and background and contributed papers are summarized. Information is given on the form and availability of final reports.

IN NOVEMBER of 1955, the Forestry Division of the Food and Agriculture Organization of the United Nations received budget approval for a conference on building boards at the technical level, patterned approximately after a consultation held in Rome in 1952 on raw materials for more paper[3] and a Latin-American meeting of experts on the pulp and paper industry[4] held in Buenos Aires during October and November of 1954.

The preparation for these conferences was handled by the staff of the Forestry Division with the assistance of a secretariat composed of technical consultants from representative areas of the world. An initial meeting for the board conference was held in Rome in December of 1955, where the aims of the Food and Agriculture Organization, the scope of the meeting, and preliminary plans were outlined. A secretariat was again convened during the period of July through October 1956 in Geneva, during which time secretariat papers were prepared, background papers were reviewed, and final plans for the meeting were developed.

During the interim period between the fall of 1955 and the summer of 1956, the Food and Agriculture Organization and the Economic Commission for Europe agreed to joint sponsorship of the Consultation. The Economic Commission for Europe is concerned with the economic development of that area and, since board products are important commodities of manufacture and trade in Europe, the Timber Division of ECE was invited to co-sponsor the conference. The principal change brought about by the dual sponsorship was participation of the countries of the Soviet bloc, since they were members of ECE but not of FAO.

The actual conference was held at the Palace of Nations, Geneva, Switzerland, January 21 to February 5, 1957. The attendance totaled approximately 360 persons from 35 countries. Documentation was voluminous. There were a total of 119 papers. The information generally available in the United States is meager on what the meeting was, why it was held, and what is and will be available in the form of reports and other publications.

It is the purpose of this paper to present information that will assist those interested in insulation board, hardboard, and particle board processes, manufacture, and use with the scope of the consultation, its aims, and how best to use information available from it.

Scope of the Meeting

The Food and Agriculture Organization of the United Nations is maintained in Rome, Italy, with regional offices in other parts of the world. There are more than 85 member countries.

[1] Presented at Session VI, Composition Board, FPRS 11th National Meeting, June 23–28, 1957, in Buffalo, N. Y.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Summarized in "Raw Materials for More Paper, Pulping Processes and Procedures Recommended for Testing," FAO Forestry and Forest Products Study No. 6, Rome.

[4] "Report of the Latin American Meeting of Experts on the Pulp and Paper Industry," United Nations Economic Commission for Latin America, Technical Assistance Administration, and Food and Agriculture Organization.

The Author: Wayne Lewis received a B.S. degree in civil engineering from the University of Wisconsin in 1936. He joined the FPL staff after eight years with the Wisconsin Highway Department. At the FPL, he is an engineer on strength and factors affecting strength of wood and wood-base materials.

Broadly, it proposes to assist in developing a better standard of living through improved nutritional and agricultural practices.

Because of present activity in board manufacturing, the possibilities of improving standards in less developed countries, and the need for interchange of information among peoples from countries that have established industries, it was deemed sufficiently important by representatives of member governments to justify a technical consultation. Secretariat paper I, "Introduction," states that it was the aim of the consultation to answer questions on 1) what processes are suitable for different kinds and types of raw material, 2) what an area with a need for board manufacture can do to satisfy the need, 3) what the possibilities are for a profitable investment of capital in a board manufacturing operation, 4) what possibilities there are of improving standards of living and economy by having board manufacture, and 5) how board products can best be used.

The writings for the sessions of the consultation were built around an outline developed in December 1955, which covered the following phases of insulation board, hardboard, and particle board technology:

I. Introduction.
II. Product description, nomenclature, and definitions.
III. World production, consumption, and trade.
IV. Raw materials.
V. Processes and equipment.
VI. Economic aspects of production and marketing.
VII. Properties, applications, and uses.
VIII. Research needs to enhance the future development of insulation board, hardboard, and particle board.

Molded products, board or panel materials of wood wool or fiber and cement, straw-cement and similar boards, and laminated paperboards were specifically excluded from consideration.

Sessions, background papers, and secretariat papers were developed around the eight subject subdivisions, with further breakdown for each type of board as necessary. Secretariat papers were prepared for each of the eight subjects by the technical secretariat. The secretariat papers had the general purpose of summarizing pertinent information and served as the base for session discussion and final reports. In addition to the secretariat papers, background papers were invited from outside authors on specific subjects covered by items III to VIII. Background papers were not considered necessary for items I and II.

Background Papers

Background papers were requested from known specialists on specific subjects pertinent to the appropriate section. Background papers totaled 103, divided as follows: Item III, 18; Item IV, 20; Item V, 37; Item VI, 13; Item VII, 11; and Item VIII, 4. The background papers are identified by a 2-number decimal system, such as 6.11; the first number, 6, identifies the broad subject, economic aspects of production and marketing, and the second number, 11, identifies a specific phase of the broad subject.

The background papers for Item III were divided into two groups. Papers were requested and received on the status of the insulation board and hardboard industry in various areas of the world as follows: Scandinavia, Europe, Canada, the United States of America, Latin America, Far East, South Africa, Oceania, Poland, Czechoslovakia, and Yugoslavia. Similar papers were obtained for the status of the particleboard industries in Canada, the United States, Colombia, Japan, South Africa, Poland, Czechoslovakia, Germany, and the rest of Europe.

Papers on raw material (Item IV) were divided roughly into groups including wood, non-wood ligno-cellulose, and other raw materials, such as additives. Background papers on wood raw material included such diverse subjects as mixed wood species, bark effect, physical form, forest and factory waste, debarking, and such species as beech, poplar, willow, and eucalyptus. Non-wood fiber and particle sources were covered by background papers on bagasse, papyrus, straw, and flax. Water, synthetic resins, and other additives were discussed in other background papers.

The background papers on processes and equipment (Item V) were divided into two broad groups, the manufacture of insulation board and hardboard, and the manufacture of particle board. The papers on fiberboard manufacture (insulation board and hardboard) were further divided into subgroups on fiber preparation, mat formation, drying and hot pressing, and post-manufacturing treatments. Papers on particle board processing were divided into groups for various phases of manufacture. The groups include particle manufacture, resin application, formation, pressing, and post-manufacturing operations. Typical of the range in specific subjects covered in the 40 background papers on processes and equipment are the following on drying and pressing of fiberboard:

5.10 Drying Fiberboard Mats for Smooth Two-Side Hardboard.
5.11 Industrial Experience in the Manufacture of Smooth Two-Side Hardboard.
5.12 The Manufacture of Insulation Board and Hardboard on One Forming Line.
5.13 Press Designs, Pressing Techniques, and Pressing Diagrams in the Manufacture of Hard Fiberboard and Hardboard.
ing for Pressing of
5.14 Hot-Water Versus Steam Heating for Pressing of Hardboards.

Background papers on "Economic Aspects of Production and Marketing," Item VI, include a range of pertinent subjects. Included are papers on factors to be considered in establishing a plant, alternate raw material considerations, size of product, packaging, influence of size of plant on investment, resin supply in undeveloped countries, costs of particle board manufacture, and economic considerations for particle board manufacture.

Background papers on properties, applications, and uses (Item VII) cover the use practice in different areas of the world for insulation board, hardboard, and particle board. Background papers are also included for specific uses and use requirements. There are papers on the use of building fiberboards as typified by United Kingdom and North American practice, and on conditioning of insulation board and hardboard before use. There are papers on the technical requirements for particle boards for furniture cores, as panel material, in building and construction work, and on the use of hardboard in rolling stock.

There were four background papers on the subject of research needs (Item VIII). One dealt with insulation board, another with hardboard, the third with particle board, and the fourth with how Soviet Russian research is oriented toward the development of a board industry.

While each of the background papers covered a specific phase of one of the major subjects, there is additional information in many of these papers that is pertinent to other phases. Whenever possible, this additional information is cited in the appropriate secretariat papers. Since approximately one-half of the total world production of insulation board, hardboard, and particle board is centered in the United States and Canada, it is understandable why authors of a substantial proportion of the background papers were North Americans. Of the total, Canadian authors contributed four papers and American authors 27.

Many of the background papers contain valuable technical information; others summarize the status of a particular part of the industry or practice on a manufacturing operation. Still others, as is to be expected when papers are solicited from so many different authors, contain nothing that is not already general knowledge, available in a more complete form or better documented elsewhere. The background papers serve the purpose, however, of containing in a single set of documents the most important phases of knowledge about insulation board, hardboard, and particle board.

Secretariat Writings

The technical secretariat, which convened during the summer and fall prior to the meeting, was charged with the responsibility of preparing secretariat papers on each major item to be considered at the consultation proper. A secretariat paper is intended to summarize all information pertinent to the subject and to serve as the basis for discussion during the sessions proper and for drafting committees. Background papers and other technical literature were combined with the technical knowledge of the consultants by the authors of the secretariat papers. The secretariat papers also have value as a bibliographical source, since appropriate literature on each subject is cited.

Secretariat Paper I is short. It merely outlines the scope of the consultation and sets the tone for the meeting. With Secretariat Paper II, "Product Description, Nomenclature, and Definitions," the problem of languages arose. The United Nations has four official languages, English, French, Spanish, and Russian. Official proceedings are reproduced in those four languages. English had been established as the working language for the consultation, so secretariat papers were written in English for translation into the other three. With exact terms as in nomenclature and definitions, there may be no exact word equivalent from one language to another. In consequence, Secretariat Paper II is based on the terms used in English-speaking countries primarily, and there may be some difficulty in making literal translations into other languages.

Secretariat Paper III, "World Production, Consumption, and Trade," presents the statistics that are important on a world basis. This paper was a particularly difficult one to prepare because of differences in methods of reporting in different places and for commodities such as particle board, for which production statistics are not available in all countries. While the figures given may not be complete, they nevertheless establish the trends of production and use.

Secretariat Paper IV, "Raw Materials," lists most of the important wood species used for insulation board, hardboard, and particle board in different parts of the world. Problems pertinent to the use of wood are discussed. These include forms required for wood, effects of bark, utilization as it pertains to integration and forest management, and the possibilities of using material undesirable for board as fuel for heat and power for board manufacture. Among the non-wood ligno-cellulosic materials discussed are bagasse, cereal straw, flax shives, papyrus, and palms. Waste paper, though usually of wood-fiber origin, was handled as one of the non-wood ligno-cellulosic raw materials.

Additives for board manufacture are discussed in two groups, 1) binders and size and 2) special additives. Water requirements are discussed separately.

Secretariat Paper V, "Processes and Equipment," is divided into two sections, one on insulation board and hardboard and the other on particle board. Broadly, the processes and equipment required are presented in flow-chart form. The different steps in manufacture are described, and the types of equipment used are discussed. For insulation board manufacture, the five steps in manufacture used are pulping, sizing, forming, drying, and additional manufacturing operations. For hardboard, the steps are pulping, sizing, wet- and air-felting, wet- and dry-pressing, heat treatment and oil tempering, humidification and conditioning, and post-manufacturing operations.

A special section is provided for combined insulation board and hardboard operation. For particle board processes and equipment, the material is presented in sections that conform to steps in manufacture. They are particle preparation, classification, drying, resin blending, formation, pressing, conditioning, and added manufacturing operations. Appended to Secretariat Paper V are summaries of operating data for insulation board, hardboard, and particle board. These show the range in figures for different plants.

Secretariat Paper VI, "Economic Aspects of Production and Marketing," deals with the most controversial of the eight subjects covered in the conference. The paper discusses investment costs, production costs, and profit. Charts and curves are presented that show the effects of mill size on unit investment, production costs, and the proportionate part of the total cost of the different board products that can be attributed to wood, resin, other additives, labor, power, and other cost factors. Other tables have such titles as:

1. Investment required for board mills.
2. Direct production costs and fixed charges for different sized mills.
3. Venture profit in board mills.
4. Minimum acceptable sales values for boards.
5. Pay-out time in years for board mills.
6. Production cost as a function of mill size—hardboard and insulation board.

Secretariat Paper VII, "Properties, Applications, and Uses," summarizes physical and strength properties for insulation board, hardboard, and discusses the use of patterns for the different products in different parts of the world. Existing standard types are described and the principal uses are presented. The paper is divided into three sections, one for each type of board.

Secretariat Paper VIII, "Research Needs to Enhance the Future Development of Insulation Board, Hardboard, and Particle Board," discusses the need for continued research on board manufacture, products, and use requirements to insure that insulation board, hardboard, and particle board will become increasingly useful and occupy their rightful place among panel materials. The paper is divided into sections on the research needs as they pertain to raw material, processing equipment and manufacture, properties, and uses.

The Secretariat papers were intended as a base on which the sessions proper would operate. They are considered as provisional texts and subject to the modifications submitted by drafting parties at the conference proper. In addition to the secretariat papers discussed in this section, there were appendices to them on the following subjects:

1. Conversion factors and equivalents.
2. World list of mills.
3. Trade associations.
4. A survey of testing methods.

Sessions Proper and Proceedings

The actual sessions for the consultation proper were held during a 15-day period in the Palace of Nations at Geneva. Attendance was by invitation, but any interested person could obtain an invitation. It was a technical consultation and not a typical intergovernmental conference. All persons attended as individuals and, except for the Soviet bloc countries, there were no official delegates or governmental delegations. Citizens of Soviet member countries apparently cannot attend such meetings except as official delegates.

The meeting itself had a definitely European flavor. Although more than 175 invitations were issued, the attendance from the United States totaled only 24, principally because of cost and time involved. This compared to a total of 87 attendees from the Federal Republic of Germany and 41 from eight Soviet countries.

While the general level of technical exchange during the conference was not balanced as ideally as had been hoped for because of the lack of balance in representation, the meeting was generally regarded as successful. The machinery manufacturers from all parts of the world were well represented, and there was ample opportunity for them to meet prospects for board plants. The representation of technically qualified professionals was sufficient to maintain discussion usually on a high technical level, and drafting committees were on a solid basis.

Each of the eight subjects required one or more sessions. A chairman and one or two rapporteurs (coordinators) were appointed for each subject from among those attending. In addition, a secretary from the technical staff of FAO was provided. It was the responsibility of drafting committees, who were appointed after the discussion on each subject, to meet in working sessions and consider the secretariat paper and, in light of the discussion, to prepare a report to supplement or append to the secretariat paper. The drafting committee reports were presented to the group in plenary session and upon acceptance were incorporated in the official proceedings of the meeting.

The proceedings of the meeting include, besides the drafting committee reports, the following:

1. General recommendations from consultation.
2. Agenda for the meeting.
3. Officers and secretariat.
4. Membership of drafting committees.
5. List of participants at consultation.
6. List of Secretariat, Background, and Contributed Papers.

The general recommendations include a resolution adopted in the final plenary session suggesting that member governments create appropriate international machinery to provide for regular exchange of economic information and statistics so that severe unbalances do not develop between productive capacity and effective demand as the board industry expands. Such machinery would also enable interchange of technical information and would provide for future consultations either on some specific phase or on an entire subject. Presumably, this recommendation will be discussed by official delegations to both the Economic Commission for Europe and the Food and Agriculture Organization at their next program and budget meetings.

Contributed Papers

One additional type of paper, known as contributed papers, was available to participants at the meeting, but these were not duplicated by FAO/ECE. There were eight of them; they were submitted by authors who felt the papers would augment the background papers solicited by the secretariat and prove useful to drafting committees. They were accepted on that basis by FAO/ECE.

These contributed papers were on such subjects as Novopan's contribution to the manufacturing process for particle board, the process and equipment for the Portugese insulation cork board industry, Fourdrinier forming and press sections for insulation board and hardboard, and the Pandia system for pulping.

Availability of Papers

Secretariat papers were reproduced in the four official languages. Background papers were reproduced in the original language as submitted and in English, the working language of the conference. Contributed papers were only in the language submitted. Proceedings of the conference proper were reproduced in the four official United Nations languages.

Texts of all papers are considered by the Food and Agriculture Organization and the Economic Commission for Europe to be provisional. Copies of the secretariat and background papers were sent to all contributors of background papers. They were made available to all participants on arrival at the meeting. Proceedings were sent to all participants after the meeting and can be obtained through the Food and Agriculture Organization, Forestry Division, Viale delle Termi di Caracalla Rome, Italy.

The secretariat and background papers are not available for general distribution, but, in accordance with recommendations of the consultation, should be available in printed form as soon as processing can be completed. It was the recommendation of the final plenary session that the secretariat papers, amended and revised as required by drafting committee reports, be published this year. The recommendation was also adopted that the background papers be published as soon after the secretariat papers as possible.

Background papers also have been released for publication elsewhere. It was announced by FAO/ECE that permission had been granted to republish background papers in journals, provided permission be obtained from the authors and proper acknowledgement made to FAO/ECE on the origin of the paper from those prepared for the consultation.

Yield of Pine Pulp Chips by Sawlog Size

PAUL R. KRAMER

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The relationship of sawlog size to volume of residue chip production was studied in a medium-sized Texas mill. As expected, small logs produced a larger yield of residue chips per unit of volume than do larger logs.

THE PRODUCTION OF PULP CHIPS from sawmill residues is rapidly becoming an important adjunct of pine sawmill operations in Texas and the South. Improved equipment design and operation and increased familiarity with the product requirements have led to the conclusion that many relatively small sawmill operations are suitable sources of pulp chips.

However, considerable basic information regarding processing costs and yields are incompletely known. Data are needed concerning the volume of chips that result from processing specific quantities of logs into lumber. Also, information is needed to determine the economic status of chip production versus lumber, or alternate products, from various log sizes and grades. The Texas Forest Service is initiating studies with respect to this phase of the pine utilization problem in Texas. This is the first of these studies to be reported.

Location of Study

The study reported in this paper was conducted at the Atlanta Lumber Company, Atlanta, Texas. This is a circular mill that cuts approximately 30 thousand board feet of pine lumber (green chain tally) per day. The attendant equipment for chip production includes a 26-inch Cambio Debarker, a Soderhamn HF-60 chipper, and a two-deck Link-Belt, 4 by 8 foot screen with mesh sizes of 1¾ inches and ¼ inch. Chips are blown into van-type trailers and hauled about 65 miles to the purchasing pulp and paper mill. A fleet of four vans and two tractors is utilized on the chip haul. The average haul amounts to about 22 tons of chips per load.

The sawed products at this mill consist entirely of one-inch and two-inch pine lumber. Although the chippable sawmill residues are completely utilized, no lumber, unless shorter than four feet, is permitted to go into the chipper.

Design of Study

The purpose of this study was to determine the volume of residue pulp chip yields from diameter-segregated classes of pine sawlogs. Four log diameter classes were used, and the number of logs in each diameter class was established in accordance with the anticipated yield of chips. While a 16-foot log was recognized as a standard log length objective, some departure was necessary. The majority of logs used in this study, however, were 16 feet long. Logs were carefully measured for length, top and butt diameter, and gross and net volume in board feet. A piece tally of lumber was made for each diameter class of logs. Marketable chips were also collected and weighed for each diameter class of logs. The entire study was repeated after an interval of one month to appraise the validity of the data obtained from the first test.

Results of Study

Table 1 presents the basic data obtained from the two separate tests made during the study. This table expresses the yield of green chips for each diameter class group of logs in terms of the Doyle, Scribner, and International ¼-inch log rules. The chip yields are given in pounds per board foot of gross log scale. The Doyle Log Rule figures used for the smallest diameter class of logs are conventional values. In other words, six, seven and eight inch logs were given a volume equivalent to their length.

As expected, small logs produce a larger yield of residue chips per unit of volume than do larger logs. The rate with which chip yields change in relation to changes in log size may be expressed mathematically.

Analysis of Data

The test results indicate that there are small differences in the per unit volume yield of green, marketable pulp chips from one test (A) to another (B) for identical log diameter class groups. However, these differences are largely traceable to changes in the mean diameter of the log sample used. Statistical analysis reveals that significant correlation exists between the chip yield data for test A and that for test B. The correlation coefficient was 0.911, with three degrees of freedom. It was further found that high-order correlations exist between mean log diameter and chip yield for each of the two separate tests. These computations suggested the feasibility of combining the results from both tests for a closer examination of the dependence of chip yield on log diameter.

Table 1.—SUMMARY OF PINE PULP CHIP YIELDS BY LOG DIAMETER CLASSES

Log diameter class (In.)	No. logs	Green lumber tally (b.f.)	Yield of chips (lb.)	Chip yield per board foot gross log scale*		
				Doyle (lb.)	Scribner (lb.)	Int. ¼" (lb.)
		TEST A				
4.6– 7.5"	50	1,172	5,620	7.2	5.1	4.6
7.6–10.5"	30	1,446	4,815	5.8	3.8	3.0
10.6–13.5"	20	1,613	3,180	2.7	2.2	1.8
13.6"+	15	2,164	3,555	2.0	1.8	1.6
Total	115	6,395	17,170	3.8	2.9	2.5
		TEST B				
4.6– 7.5"	50	990	5,165	7.0	5.0	4.6
7.6–10.5"	30	1,063	4,560	6.9	4.2	3.4
10.6–13.5"	20	1,462	3,890	3.6	2.6	2.3
13.6"+	15	1,827	3,335	2.1	1.8	1.6
Total	115	5,342	16,950	4.2	3.1	2.7
		TESTS A & B				
Total	230	11,737	34,120	4.0	3.0	2.6

*Green weight basis and moisture content of approximately 100 per cent (O.D.).

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A regression analysis of chip yield on log diameter was made for each of the log rules listed in Table 1, and also for green-chain lumber tally. One of these regressions,[1] that for the International ¼-inch Log Rule, is shown in Fig. 1.

Application of Results

The major cause of variability in pine residue pulp chip yields between individual sawmill operations is the kind and degree of utilization standards in effect as a normal part of the mill operation prior to the point of residue utilization. The prime cause for variation in chip yield within an individual mill, however, is directly related to log size. This assumes that the average mill practices consistent log utilization or product standards over extended periods of time.

Unfortunately, there are no practical means for evaluating residue chip yields solely on the basis of green-chain lumber tally. The use of log diameter for this purpose is quite logical. Mill operators at most mills maintain some sort of bull-chain log record sheets. These are generally suitable for the purpose of predicting residue chip yields.

Table 2 presents estimated chip yields in pounds per board foot gross log scale for the several log rules previously listed. The table has been prepared by substitution from the independently computed regression curves. The 6-inch and 7-inch log diameter class yields are omitted from the Doyle Rule estimates since they are biased by the method of log volume computation.

Table 2 is suitable for use in any pine mill where there is no by-product utilization from residues other than for pulp chips. The values will not be valid for chip estimates where log defect (cull) exceeds a reasonable average for this species. This might tentatively be set at 5 per cent. Its accurate identification will have to await specific studies for that purpose.

To derive estimated chip yield, it is only necessary to know the average log diameter and the gross log scale. For operators of mills who happen to have log diameter information but do not have, or care to compute, gross log volumes, Table 3 has been prepared so as to use log diameter and green chain lumber tally. This table has also been expanded to show the value of residue chips produced per thousand board feet of rough, green lumber when chips are valued at $6.00 per ton.

Actually, it would be quite possible to use the above tables for chip estimates at mills where some form of by-product utilization other than residue chips is in effect. This could be accomplished by obtaining the weight of such alternate products from a stated period of mill operation. After converting this weight to pounds per board foot of lumber produced during that period, this figure could be subtracted from the tabular yield estimates. The difference would closely approximate the residual available for pulp chip production.

[1] Pictorial regression formulae are available upon request to the Forest Products Department, Texas Forest Service, P. O. Box #460, Lufkin, Texas.

Table 2.—SUMMARY OF ESTIMATED YIELD OF PINE RESIDUE PULP CHIPS BY MEAN LOG DIAMETER AND BY LOG RULE

Meam log diameter (In.)	Estimated chip yield per board foot gross log scale*		
	Doyle (lb.)	Scribner (lb.)	Int. ¼" (lb.)
6†	-	(5.5)	(5.1)
7	-	4.8	4.3
8	9.8	4.3	3.7
9	6.6	3.7	3.1
10	4.6	3.2	2.6
11	3.5	2.8	2.2
12	2.9	2.5	1.9
13	2.5	2.2	1.7
14	2.2	1.9	1.6
15	2.1	1.7	1.5

*Green weight basis and moisture content of approximately 100 per cent (O.D.).

†Values for 6-inch log diameter are slightly beyond the limits of the contributing data, and should be used with caution.

Table 3.—ESTIMATED YIELD OF PINE RESIDUE PULP CHIPS BY MEAN LOG DIAMETER AND GREEN-CHAIN LUMBER TALLY

Mean log diameter	Estimated chip yield per board foot—lumber tally (lbs.)	Value of chips per M board feet of lumber produced ($)
6	5.5	16.50
7	4.8	14.40
8	4.2	12.50
9	3.6	10.80
10	3.1	9.30
11	2.7	8.00
12	2.3	6.90
13	2.0	6.00
14	1.8	5.30
15	1.6	4.80

Summary

An examination has been made of the relation between residue pulp chip yields and log diameter for a series of pine logs at a medium-size pine sawmill in Texas.

The data indicate that there is a close relationship between log diameter and chip yield per unit of volume. Several measures of this relation are provided in tabular form and relative chip yields are also expressed in terms of gross selling price.

Application ot these chip yield figures to other installations should be made only with due regard to utilization practices or standards where they differ from the mill described. Changes in headsawing equipment will not materially affect such an application.

The Texas Forest Service plans to check the application of these data to other types of pine sawmills as time and opportunity permit. Preliminary indications are that the estimates are quite reliable for widely divergent types of operations.

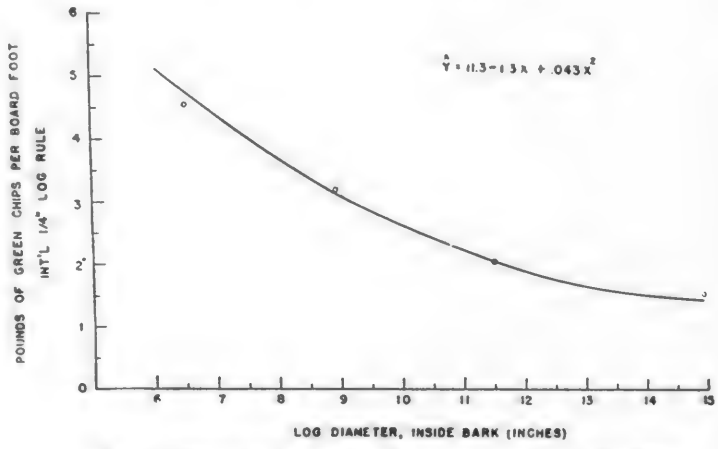

Fig. 1.—Regression of pine residue pulp chip yield (Y) on mean sawlog diameter (X) for circular mill cutting 25 to 30 M. bd. ft. daily.

Around the World in Forest Products Research and Development

Upward Trend in Forest Products Output

Although little change was recorded in the total timber harvest from the world's forests, the output of wood for industrial purposes in 1956 increased by two perecent over that of 1955, the Food and Agriculture Organization reported recently.

According to the FAO Yearbook of Forest Products Statistics, removals of fuelwood decreased by three per cent, which indicates the worldwide change from wood fuel to other sources of energy. The estimated market value of all the main primary forest products reached $27,700 millions, surpassing by $600 million the value of these products in 1955.

The total world sawnwood output in 1956 was slightly more than 295 million cubic meters, of which coniferous species accounted for about 80 per cent. The United States was the leading producer with 88.5 million cubic meters; the Soviet Union followed with 76 million, and Canada reported 19 million cubic meters.

About 58 per cent of the total world plywood production of 11.30 million cu. m. came from North America. The greatest percentage growth, 22 per cent, was reported in Asia. Plywood output in Japan increased from 683,000 cu. m. in 1955 to 852,000 cu. m. in 1956.

Wood utilized for paper, paperboard and fiberboard in 1956 was about three per cent greater than in 1955, whereas wood used for sawnwood and plywood decreased by about one per cent.

Wood-pulp production in 1956 increased by six per cent over 1955, reaching a record of nearly 49 million tons. The North American share in this output was about 60 per cent. Production of pulp products—newsprint, paper other than newsprint, paper board and fiberboard—totaled nearly 63 million tons. North America and Europe (excluding the USSR) produced more than 86 per cent of this volume. Of the pulp products, newsprint showed the greatest growth in output, 11.18 to 12.04 million tons (about 8 per cent) followed by fiberboard, which increased by six per cent from 3.15 to 3.34 million tons.

World output of particle board was estimated at 705,000 tons, of which nearly 79 per cent was produced in Europe. The largest volume, 162,000 tons, was reported from the Federal Republic of Germany, and the United States was second with 125,000 tons.

World trade declined in both sawnwood and plywood. According to the figure reported to FAO, world exports of sawnwood were nearly 10 per cent lower in 1956 than in 1955, and plywood exports were down about four per cent. Wood-pulp exports increased by nearly three per cent, newsprint by more than five per cent, and paper other than newsprint six per cent. Paperboard exports declined by five per cent.

Scanning World-Wide Forest Products Publications

Australia

Ripping Logs with Power Chain Saws. W. M. McKenzie. C.S.I.R.O. Forest Products Newsletter. No. 234

Designed originally as a portable cross-cutting machine, the power chain saw is less efficient in ripping than regular ripping saws, but its use can be worthwhile.

When the gouge-type chain was developed, ripping with chain saws became common. The gouge-type chain with a tooth edge for severing fibers across the bottom of the kerf requires less power, keeps cooler, wears longer, and cuts straighter than the scratch-type chain, when used for ripping. Efficiency is increased if the motor end leads the tailstock end.

More power and time is needed for ripping than cross-cutting, which requires the motor to sustain a heavy load for periods up to 30 min. or more. Electric motors are better for sustained loads. Successful ripping requires a means of ensuring a reasonably accurate cut. Three types of rigs are described.

The first is a cross-cut saw with adequate power for ripping and a cutter bar that can be swivelled for horizontal cutting. Planks are spiked to the ends of the log, with top edges horizontal, and at a height where the cut is required. An end of each plank projects, holding another plank to carry the motor end of the chain saw.

The second rig, used in Europe, is a steel staging that may be set up over a log. The chassis is adjusted for height by screws at each of the legs, and supports a movable carriage with a bow to clear the log. Saw motor and tailstock are supported by the carriage, which is propelled by a hand winch, or may be motorized. The rig eliminates fatigue, enables the operator to avoid fumes and sawdust, it is precisely guided, and reasonably accurate flitches may be sawn by lowering the chassis.

In America, a heavy-duty cutter bar and chain is used for breaking down large logs in the pond. It is mounted on a deck or float, and the floating logs are drawn through.

At the stage where a machine is required for regular breakdown of big logs at the sawmill, the use of a chain saw is unlikely to be the most economical solution because its cutting action is less efficient than that of conventional ripping saws, and because of high power consumption and greater saw maintenance.

Japan

Mechanical Properties of Chipboard Made of Flat Flake Particles. T. Maku, H. Sasaki, and R. Hamanda. Journal of the Japan Wood Research Society, V. 2, no. 4. [English Summary]

The authors found the relationship between the mechanical properties and the specific gravity in chipboard panels made of flat flake particles of Hinoki (Chamaecyparis obtusa S et Z): type 1, 5 cm long, 1.2 cm wide, and 0.2, 0.5 or 1.0 mm thick; type 2, 1.3 cm long, 1.2 cm wide and 0.2, 0.5, or 1.0 mm thick. They also discuss the bending failure of its beam.

The relations of tensile and compressive strength, and their elastic modulus to specific gravity are linear, and are free of the effect of length and thickness of particles. However, shearing strength is markedly influenced by the thickness of particles, which seems to be caused partly by the amount of resin spread per unit area of the particles.

The elastic moduli in tension and compression are nearly equal, but there are characteristics indicating that the tensile strength is slightly smaller than the compressive strength. Linear formulae are estimated experimentally between tensile strength, compressive strength, and elastic modulus. The coefficient of bending failure caused by tension was determined.

Abstracts From Current World Literature

Finishing

L. W. J. Damen. Unsaturated polyester resins in surface coatings. *Paint,* Vol. 26 No. 11, November 1956, pp. 407–410, illus.

Among the plastics which have grown rapidly in importance since the war, unsaturated polyester resins take a prominent place. They are used in combination with glass fibres to form laminates and in solution in styrene, as surface coatings.

The application of thick layers which, as unfilled coatings give a well-bodied finish, is the ideal of all craftsmen. Until recently this was not feasible because an airdrying lacquer applied thickly needs a considerable percentage of solvent which eventually evaporates to leave only a thin film. With the use of unsaturated polyester resins this ideal can be approached and even attained as, under the influence of added accelerators and catalysts, the styrene and the polyester resins copolymerize to form very hard, resistant layers.

These coatings have many other useful properties such as resistance to shock, scratching, heat such as burning cigarettes, water, ink, alcohol, oil, benzine and dilute acids. Moreover they do not sink into the wood and there is every little yellowing which makes them ideal for use on such woods as maple and birch.

For application on wood a priming coat of a polyester resin highly diluted with acetone can be used and the next coat applied after two hours. Special measures to ensure that the grain shows clearly are not necessary but the choice of stains should be selective. Because of the short pot life of the polyesters when the catalyst and accelerator have been added, no more should be mixed than can be applied in the time availester is mixed with the catalyst and another part with the accelerator. These can then be sprayed through two guns simultaneously or with two-component equipment in which mixing takes place in the gun during spraying.

Even if the lacquers have been prepared and applied with great care the top layer, having been exposed to the air during curing, will not have hardened sufficiently because of air inhibition. This thin layer of 5–10 microns will need to be removed by grinding after a curing time of about 15 hours and this may prevent the application of polyesters to surfaces with complicated mouldings or carvings. They may however be applied to nearly all types of wood, sheets of pressed wood waste and to hardboard.

Faults and failure in applying these coatings may result from draughts during the curing time, air introduced during mixing which will produce surface pitting, poor adherence on a surface which has not been cleaned sufficiently, or cracking after a few months if the resin is too hard. Particularly suitable applications for polyester resin coatings are products which are subject to considerable wear and yet must have a pleasing appearance. [F. D. C. Tech. Bul. V. 6, No. 34]

Drying finishes on wood with infra-red heat I. J. Barber and P. H. Krupp *Industrial Finishing,* U.S.A., Vol. 32, No. 12, October 1956, pp. 94–8.

Even although the heat intensities used on wood are reduced below metal processing temperatures, finishes can usually be dried very quickly with infra-red.

Flat panels carried by conveyor, either horizontally or vertically, are easy to process and, if the oven is properly designed, three dimensional shapes can also be handled. The radiated heat will penetrate films of clear lacquer up to 10mils thick but filter or sealer coats will absorb much of this heat.

The controls for these ovens can also be connected with conveyor controls so that, in the event of a conveyor stoppage, the oven would be automatically switched off to prevent damage to pieces being dried. [F.D.C. Tect. Bll. V. 6, No. 37]

Wood Structure

Bucher, Hans. The tertiary wall of wood fibers and its morphology in conifer tracheids. Holzforschung 11, no. 1: 1–16 (April, 1957). [In German; English summary]

Publications dealing with the inner layer of wood fibers bordering the cell wall toward the lumen are reviewed critically. Some observers found this layer to be an individual membrane, distinctly different from the secondary thickening of cell walls, and called it the tertiary wall (I), whereas other investigators considered it as a continuation or part of the secondary wall. A method for differentiating (I) in wood fibers has been developed. It involves delignification of small softwood sections by repeated treatment with an acidified sodium chlorite solution, staining the samples with Victoria Blue B in a specified manner, and partial swelling with dilute cuprietheylene diamine solution. This staining method makes the primary wall appear blue, the secondary wall red, and (I) blue. The differentiation also proved conclusively that it is the outer layer of the secondary wall that causes the phenomenon of ballooning, in which the primary wall has no part. The morphology of (I) has been studied in detail in *Picea excelsa, P. canadensis, P. mariana, Abies pectinata, A. balsamea, Pseudotsuga taxifolia, Pinus silvestris, P. cembra, P. insignis* (*P. radiata* D. Don), and *Larix europaea.* Several morphological structures of (I) could be distinguished, namely, membranes, coiled spirals, open spirals, various complex helices, and hyaline (gelatinous structureless) layers. These studies proved conclusively for the first time that (I) is not connected with the secondary wall. The two layers were even found to be separated by a space which sometimes showed a particular structure. The cell walls are perforated by pores, called the pits. The most characteristic bordered pits of softwood tracheids enclose a cavity with a small outlet to the lumen (porus). Whereas (I) is generally supposed to be perforated at the pit's opening, the present observations established definitely that (I) enters the pit, lining the pit cavity and covering the secondary wall, and is thus connected with the primary wall. In many respects, (I) resembles the primary rather than the outer layer of the secondary wall. Judging from its staining behavior, (I) must contain acidic groups, probably hemicelluloses related to polyuronic acids. [Bul. Pap. Chem. V. 27, No. 10]

Pathology

Basham, J. T. The deterioration by fungi of jack, red, and white pine killed by fire in Ontario, Can. J. Botany 35, no. 2: 155–72 + 3 plates (March, 1957).

The nature, causes, and rate of pathological deterioration of jack, red, and white pines killed by fire in the Mississagi region of Ontario in 1948 were studied to determine the practicality and probable duration of profitable salvage operations in such stands. Blue and brown sapwood stains appeared in all species one year after the fire and became extensive during the succeeding three years. Sap rot was noted two years after the fire; five years after the fire most of the sapwood was affected, and in some cases this rot extended into the heartwood. Three fungi, *Peniophora gigantea, Polyporus anceps,* and *Polyporus abietinus,* were isolated consistently from white sap rots, whereas *Fomes pinicola* and *Fomes subroseus* were recovered from many of the brown sap rots. The increase in the volume of heart rot encountered during the course of the study, chiefly associated with *Fomes pini,* was much greater than that observed in living pine over a similar period, and for this reason the excess was considered as a form of deterioration. The average rate of radial penetration of visible deterioration was significantly faster in trees with widely spaced annual rings in the outer portion of the bole than in slow-growing trees. Variations in the severity of burn in individual trees or stands apparently had little effect on the rate of pathological deterioration. [Bul. Pap. Chem. V. 27, No. 9]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiberboard and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

Review of FPRS National Meeting Papers

Modern Woodworking Methods

Clifford A. Baker, Technical Service Supervisor, Woodworking Trades Coated Abrasives & Related Products Division, Minnesota Mining and Mfg. Co., St. Paul, Minn. Session II, Wood Machining, FPRS' 11th National Meeting, June 23–28, 1957, Buffalo, N. Y.

Mass-production techniques have been applied to many aspects of woodworking, but final finishing remains something of an art. Although much development has gone into synthetic finishing materials, the fact remains that any flaw in the finished white wood will most certainly show up in the finished topcoats. Attempts to hide such flaws without reworking the these often work acceptably well, but white wood have been made, and require extra time and money.

Two recent developments in wood finishing methods that may profoundly affect the woodworking industry are, first, the system of finishing white wood as well as sealer and wash coats with a straight-through sanding principle, or a series of straight-through machines linked by conveyors; and second, a method of sanding the sealer with a wheel made of coated abrasive leaves, called the "PG" wheel.

The stroke sanding principle currently used is a good one, but has limitations, notably, the leave-off or lap-over marks on a work piece (since the belt is narrower than the work piece), and the time needed to put a piece onto the sander table and remove it when sanding is complete.

Several makes of the straight-through machine are being produced. They can be obtained in several machine widths, up to 50 inches, and coated abrasive belts are especially made for each width, so that the belt covers the whole work piece at once and eliminates the problem of leave-off marks. Because of the straight-through action, work pieces can be fed into the machine by conveyor and carried off in the same manner after sanding, thereby cutting down handling time.

Two or more of these machines can be hooked in tandem and equipped with an abrasive belt grit sequence so that a work piece can be completely finished with a three-grit sequence from the time it is put on the first conveyor (which can be right after trimming) until it is taken off after final grit sanding.

The second method is the use of the "PG" wheel with a construction especially designed for woodworking. The "PG" wheel consists of coated abrasive leaves in a wheel of 16-inch diameter. There are nearly 1,000 leaves, which will sand flat stock or take the shape of a contour piece and hold that shape throughout the life of the wheel, or until reshaped. The leaves, made of cloth-backed garnet mineral, are fastened to the center by a tough, heat-resistant, resin-and-glue bond.

In actually production runs, the "PG" wheels put final finishes on a variety of pieces, and are being used for sealer and wash-coat sanding. Where used, the operation is straight-through, with conveyors used for feeding and take off. There is to date no machine designed to accommodate the wheels in the woodworking industry; where wheels are in use a machine has been built or an old one modified so the wheels could be used. The wheel fills a very utilitarian need on a lathe spindle for off-hand operations where the emphasis is on contoured stock-moldings and the like.

The wide-belt principle, as employed by a new model of the straight-through machine with the abrasive belt mechanism mounted above rather than below the machine, results in a burnishing-type process. After a perfectly even sanded surface is obtained, fine sandpaper is used to glaze the surface There are no compounds or liquids involved. Examination of the results reveal a very highly polished board in the white, which at first glance appears to be sealed, sanded and waxed to a high degree of luster.

Complete automation can be visualized for the future furniture finishing process, which implies pre-finishing from dimensional, rough stock right through sealing and filling to top coat application and rubbing. Also implied in complete automation is the end of the finishing room as it now exists.

New methods as well as new products are needed. A method suggests a product revision; the revised product makes it possible to upgrade the methods. Of particular importance in all these developments is the conservation of natural solid wood stock by achieving less waste and fewer rejects.

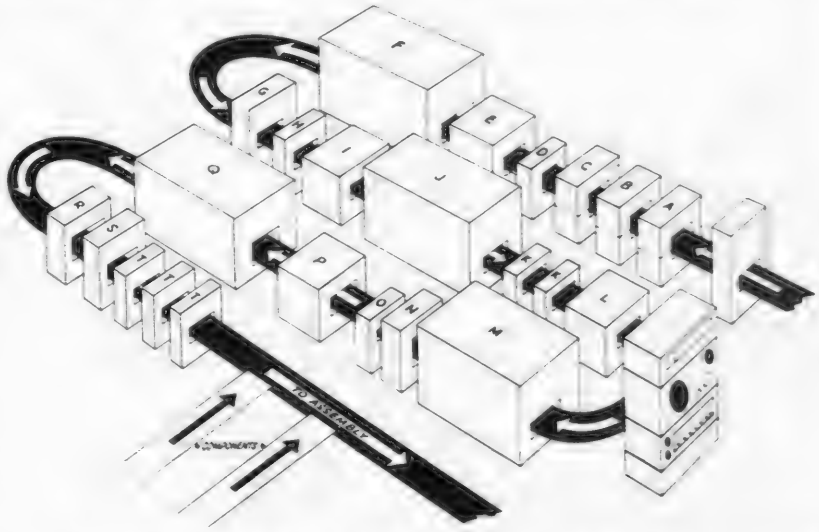

Fig. 1.—Letter key to diagram of automated finishing line of the fututre: A—Overslung sanding machine with a 3/0 coated abrasive belt. B—Overslung sanding machine with a 5/0 coated abrasive belt. C—Overslung sanding machine with a 10/0 coated abrasive belt. D—Cleaning brush. E—Roller or spray application of stain and/or wash coat. F—Heat lamps for drying stain or wash coat. G—Stain or wash coat sanding with overslung sanding machine with a 10/0 coated abrasive belt. H—Cleaning brush. I—Application of filler. J—Heat lamps to dry filler. K—Brushes for wiping filler. L—Roller or spray application of sealer. M—Heat lamps for drying sealer. N—Sealer sanding with overslung sanding machine with a 10/0 coated abrasive belt. O—Cleaning brush. P—Roller or brush or spray application of top coat. Q—Heat lamps for drying top coat. R—Top coat sanding machine with a waterproof coated abrasive belt, grit 360, and lubricant. S—Top coat finishing machine with waterproof coated abrasive belt, grit 500, and lubricant. T—Cleaning and polishing brushes.

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Beech for Crossties. E. P. Wyman. Evaluates the characteristics of beech for use as crossties. Beech Utilization Series No. 15, Northeastern Forest Experiment Station, 102 Motors Avenue, Upper Darby, Pa.

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Report on Project 301–A. Preservative Treatment on Fence Posts by Cold-Soaking in Pentachlorophenol-Fuel-Oil Solutions. C. S. Walters and K. R. Peterson. University of Illinois Agricultural Experiment Station, Urbana, Ill., Forestry Note No. 70.

Penetration and Exudation of Oil in Sections of Pine Poles Treated with Creosote-Pentachlorophenol Mixtures. H. P. Sedziak. Report 0–175, Forest Products Laboratories of Canada, Dept. of Northern Affairs and National Resources, Ottawa, Ontario.

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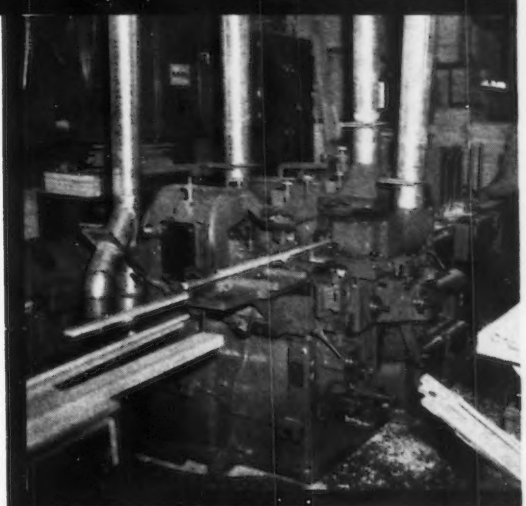

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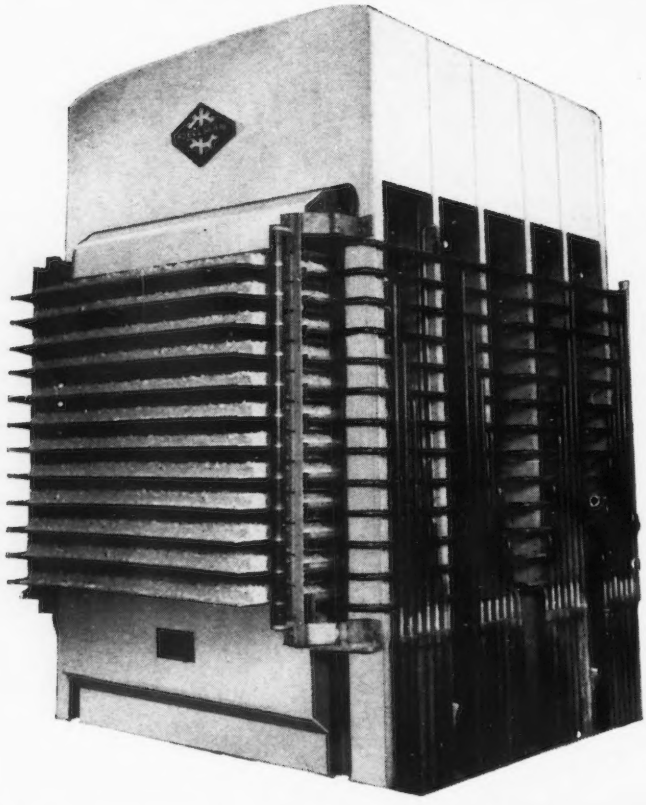

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